

NCP1568D PoE Input USB-PD Evaluation Board User's Manual

Circuit Description

This evaluation board manual describes a 45 W universal input 5 V, 9 V, 15 V and 20 V output evaluation board for Power over Ethernet to USB-PD applications. This featured power supply is an active-clamp flyback topology utilizing ON Semiconductor's NCP1568D PWM controller, NCP51530 HB Driver, NCP4308 SR Controller and FUSB3307 USB-PD Controller. This design note provides complete circuit schematic, PCB, BOM and transformer information of the evaluation board. It also provide efficiency, transient response, output ripple and thermal data of the evaluation board.

This design utilized NCP1568 and NCP51530 for the active clamp flyback topology. Active clamp flyback topology effectively recycles the leakage energy. Another feature of this topology is the ZVS operation of the power MOSFETS. Because of no leakage losses and ZVS operation, this topology is suited for high frequency operation which results in size reduction of the transformer. Hence Active clamp flyback topology is well suited for high power density sub 100 W power supplies.

NCP1568D is a highly integrated DC-DC PWM controller designed to implement an active clamp flyback topology. It features adaptive frequency scheme which optimizes frequency of operation and hence the efficiency over all load and input voltages. The NCP1568 features a HV startup circuit.

NCP51530 is a 700 V high side and low side driver with 2 A current drive capability for DC-DC power supplies and inverters. NCP51530 offers best in class propagation delay, low quiescent current and low switching current at high frequencies of operation. This device is tailored for highly efficient power supplies operating at high frequencies.

NCP4308 is high performance driver tailored to control a synchronous rectification MOSFET in switch mode power supplies.



ON Semiconductor®

www.onsemi.com

EVAL BOARD USER'S MANUAL

FUSB3307 is a fully compliant, highly integrated USB Power Delivery (PD) power source controller that can control a DC-DC port power regulator or the opto-coupler in the secondary side of an AC-DC adapter.

Key Features

- PoE Compatible DC-DC Input Voltages (37 V – 57 V)
- High Full Load and Average Efficiency
- Low Standby Power
- Very Low Ripple and Noise
- High Frequency Operation up to 400 kHz
- Thermal and OVP Protection
- Adaptive Frequency Operation based on Input and Output Load Conditions
- Adaptive ZVS Operation
- Inherent SCP and OCP Protection
- Board Dimensions: 2.23" x 1.34" x 0.58"

Specifications	
Output Voltage	5, 9, 12, 15, 20 V
Ripple	< 2%
Nominal Current	3 A / 2.25 A @ 20 V
Max Current	3 A / 2.25 A @ 20 V
Min Current	Zero

Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCP1568D NCP51530 NCP4308D FUSB3307 FDMS86255 FDMS86101	PoE to USB-PD Adapter	37 Vdc – 57 Vdc	45 W	Active Clamp Flyback	Isolated

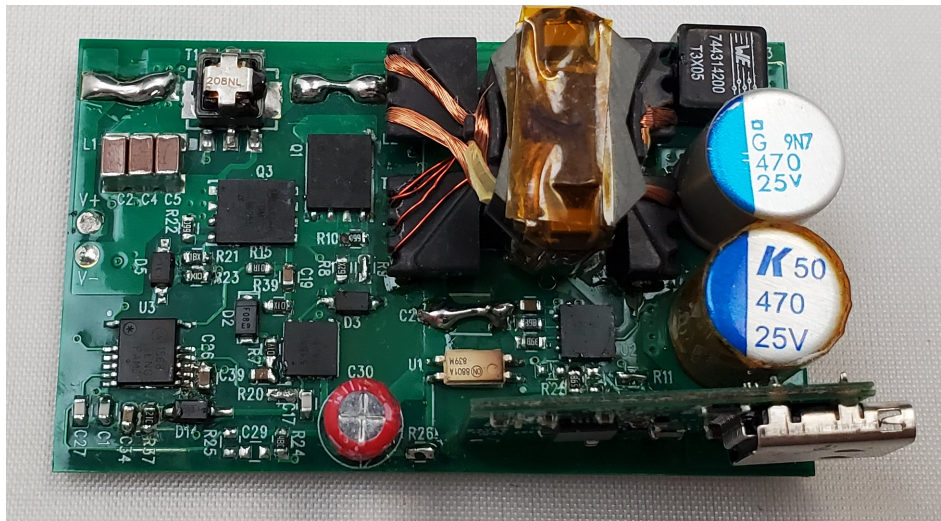


Figure 1. Top View of the Evaluation Board

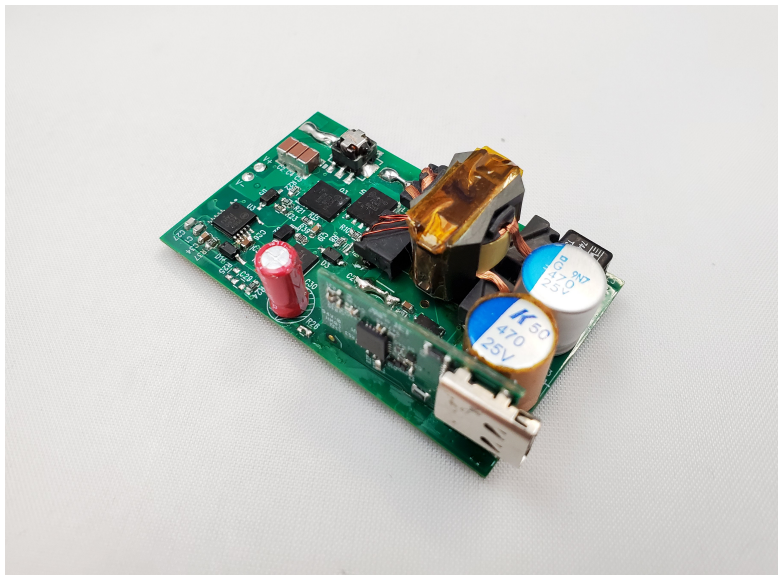


Figure 2. Full View of the Evaluation Board

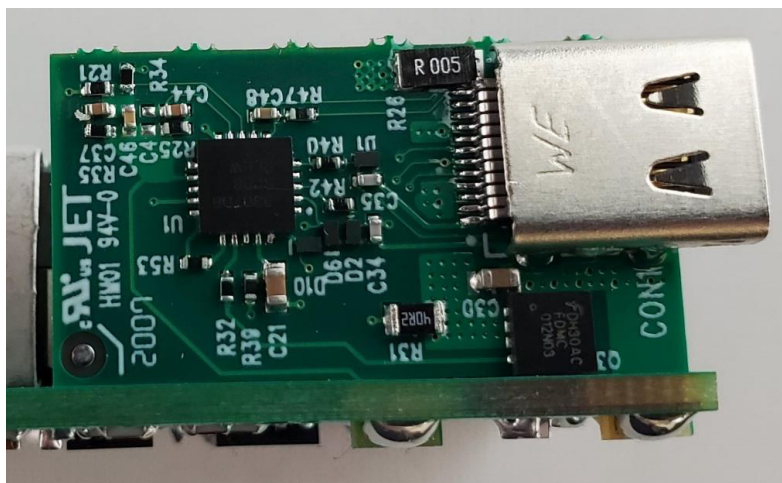


Figure 3. View of the Daughter Card

MAIN BOARD LAYOUT

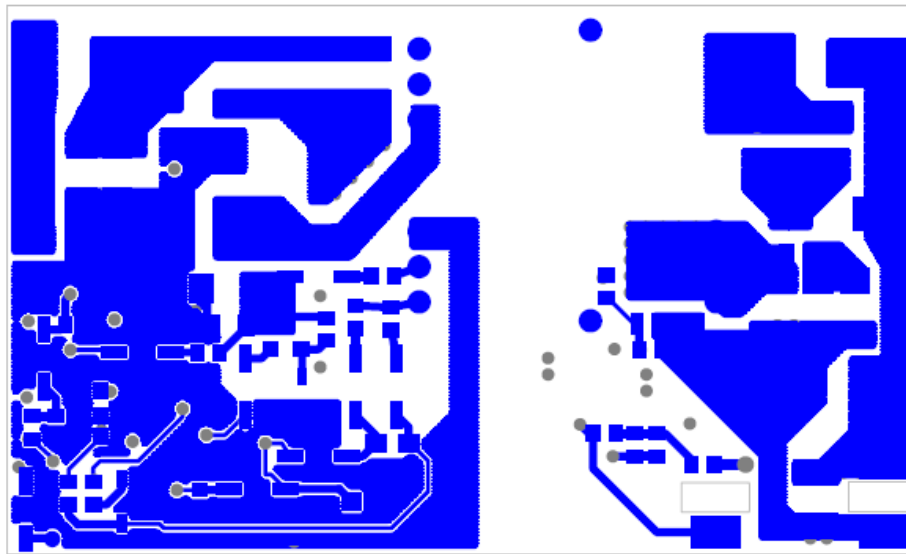


Figure 4. Main Board Top Layer

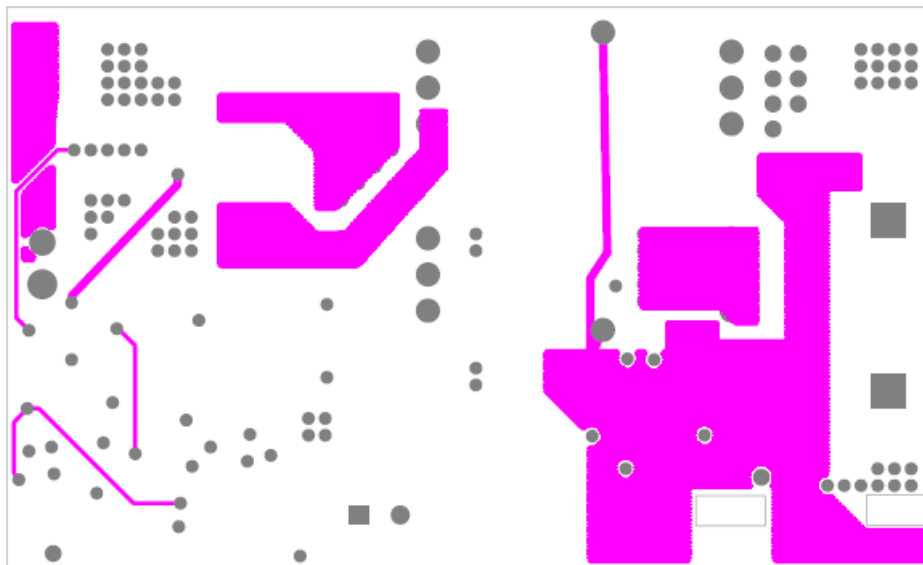


Figure 5. Main Board Inner Layer 1

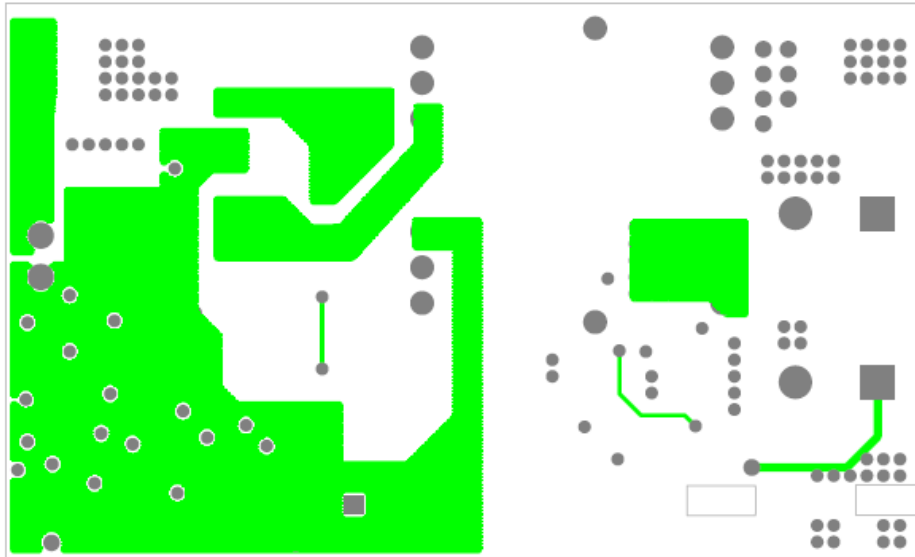


Figure 6. Main Board Inner Layer 2

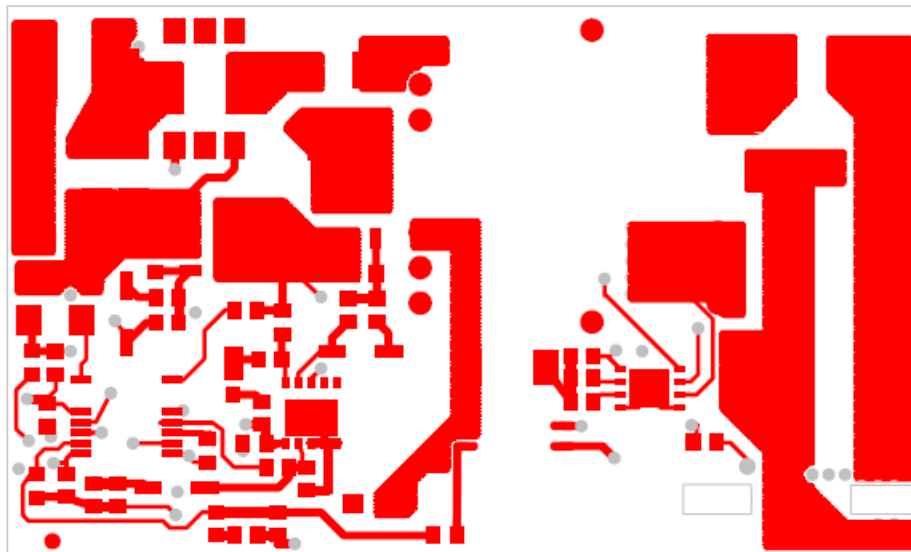


Figure 7. Main Board Bottom Layer

DAUGHTER BOARD LAYOUT

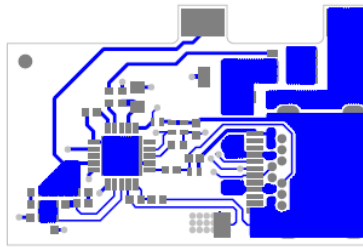


Figure 8. Daughter Card Top Layer

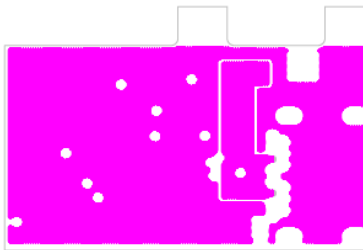


Figure 9. Daughter Card Inner Layer 1

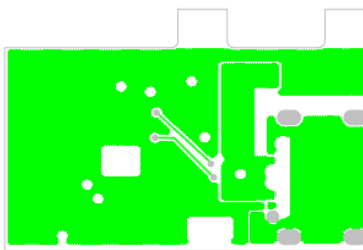


Figure 10. Daughter Card Inner Layer 2

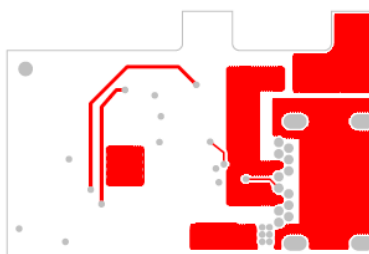


Figure 11. Daughter Card Bottom Layer

MAIN BOARD SCHEMATIC

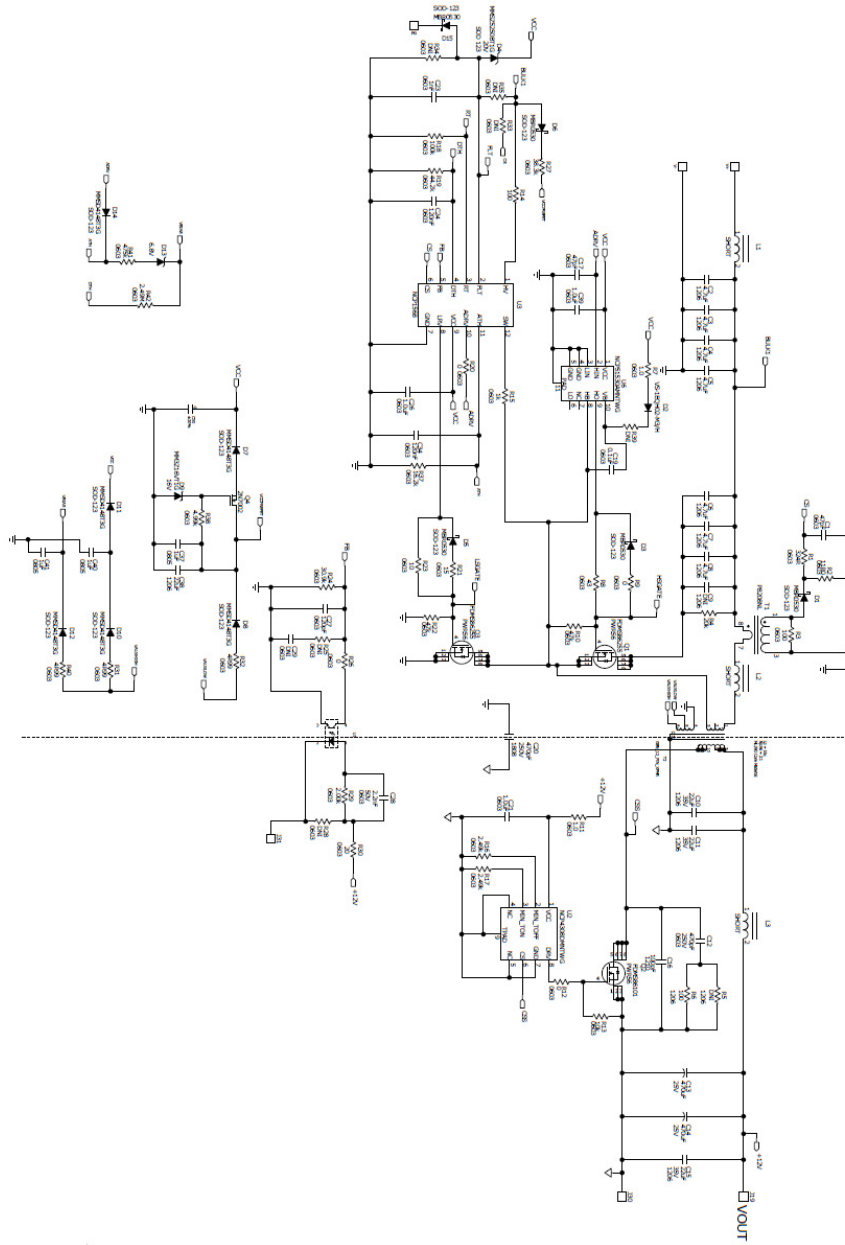


Figure 12. Main Board Schematic

EVBUM2776/D

DAUGHTER BOARD SCHEMATIC

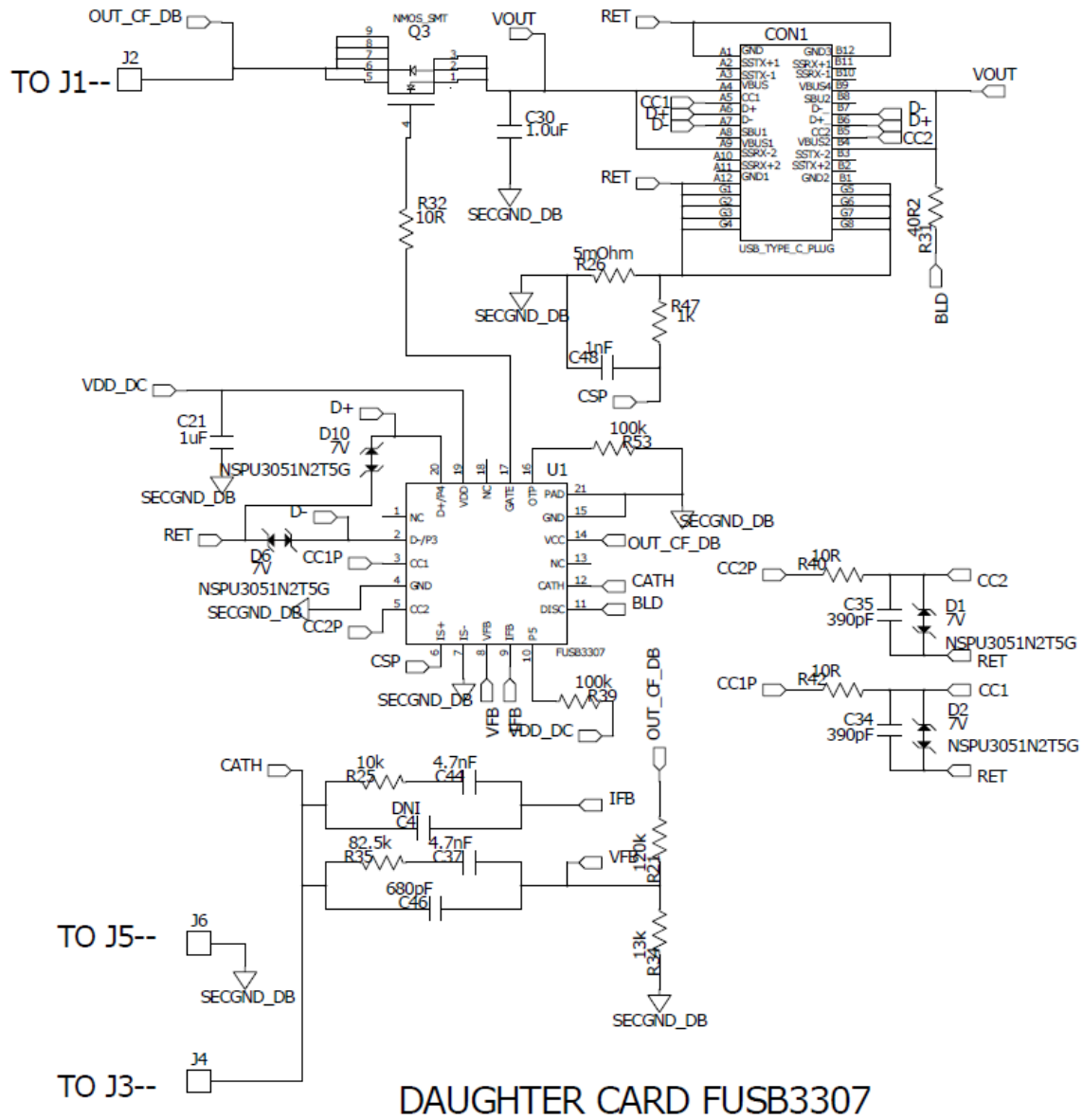
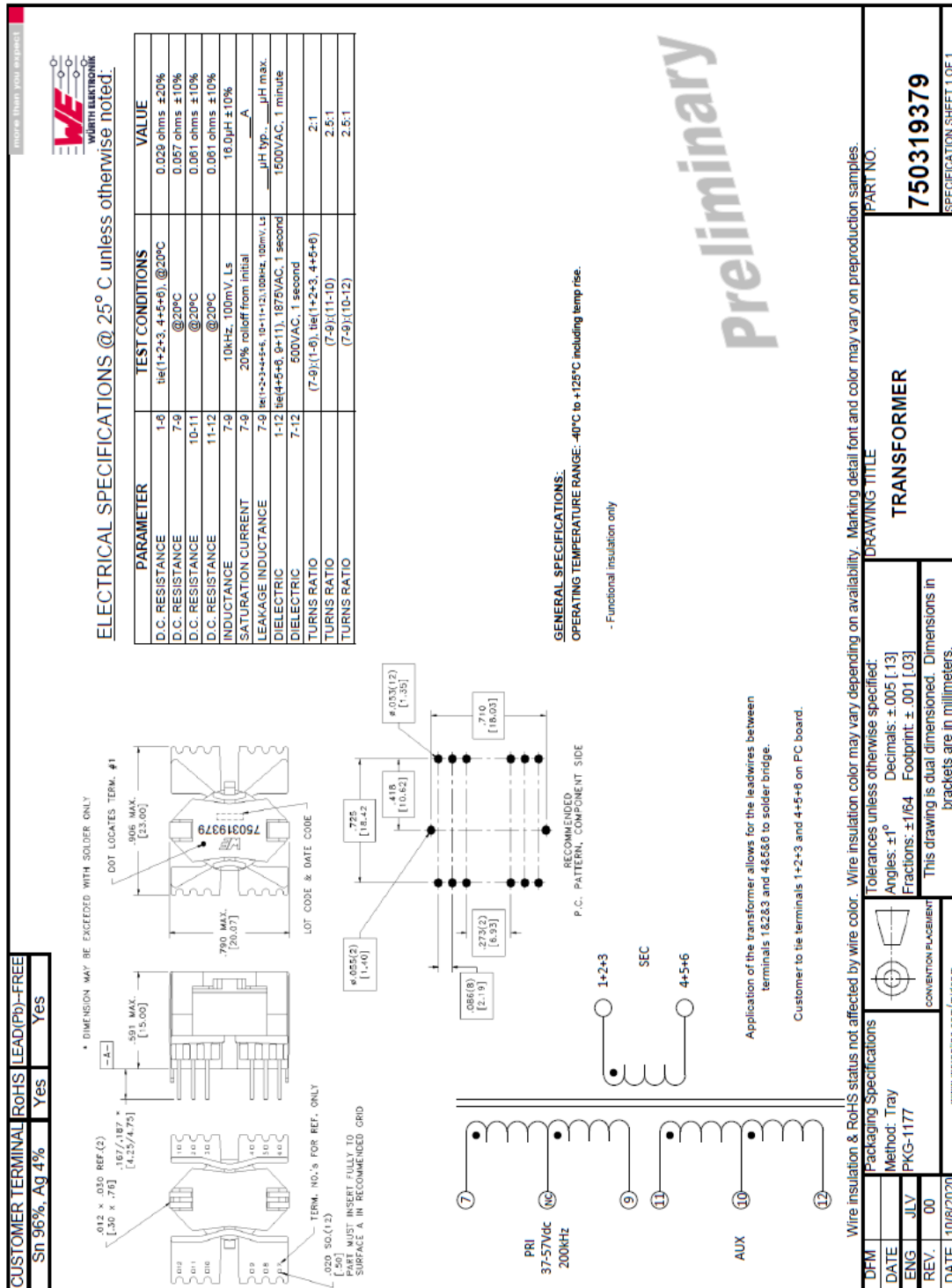


Figure 13. Daughter Card Schematic



Evaluation Board Efficiency Data

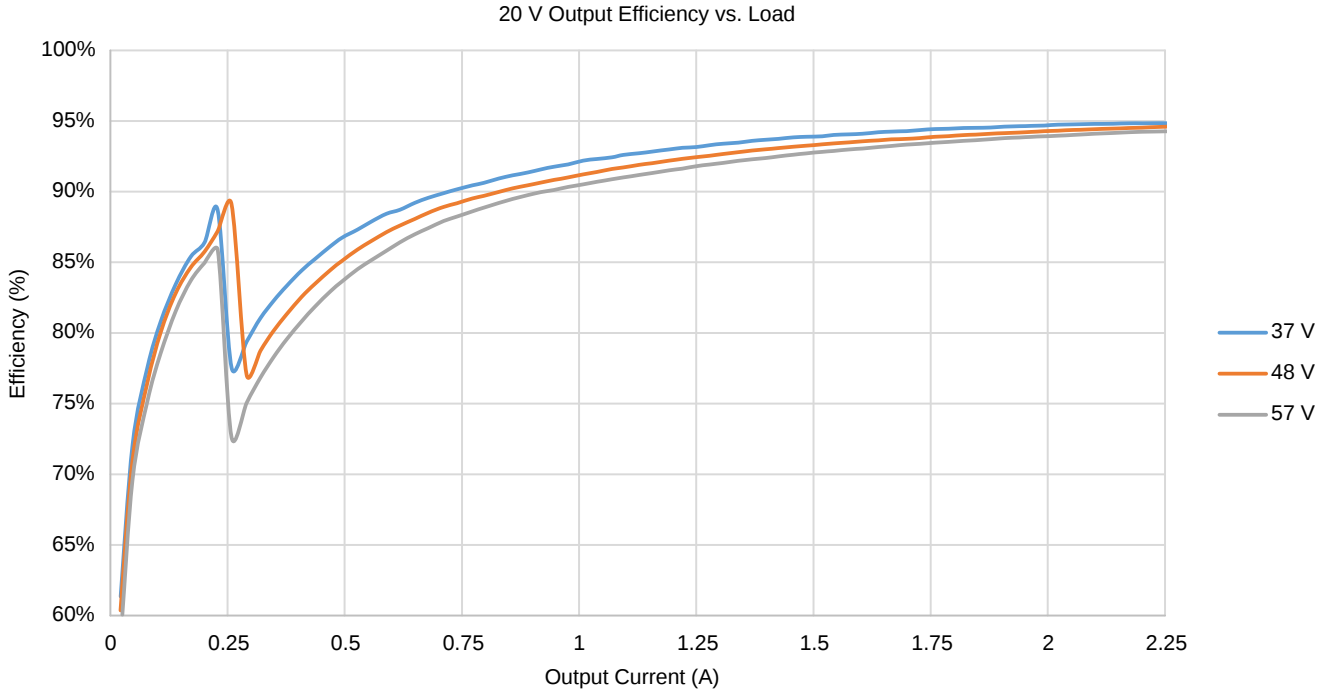


Figure 15. 20 V Efficiency Plot

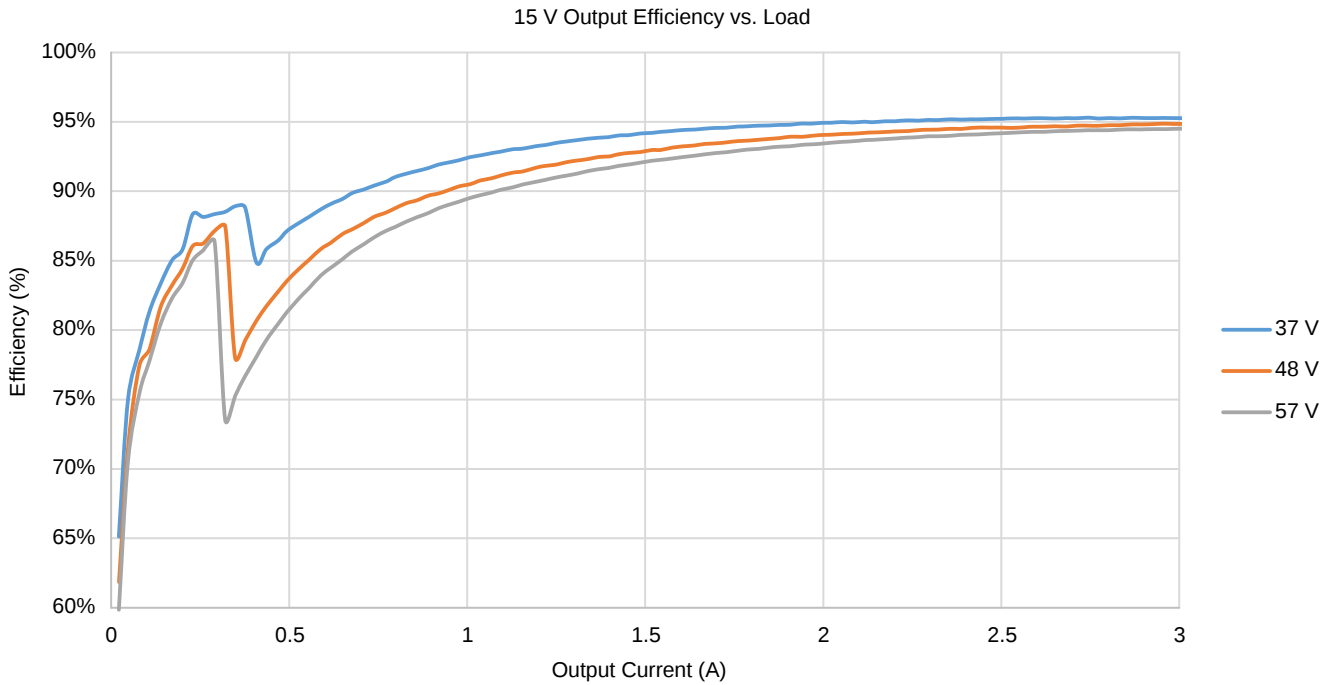


Figure 16. 15 V Efficiency Plot

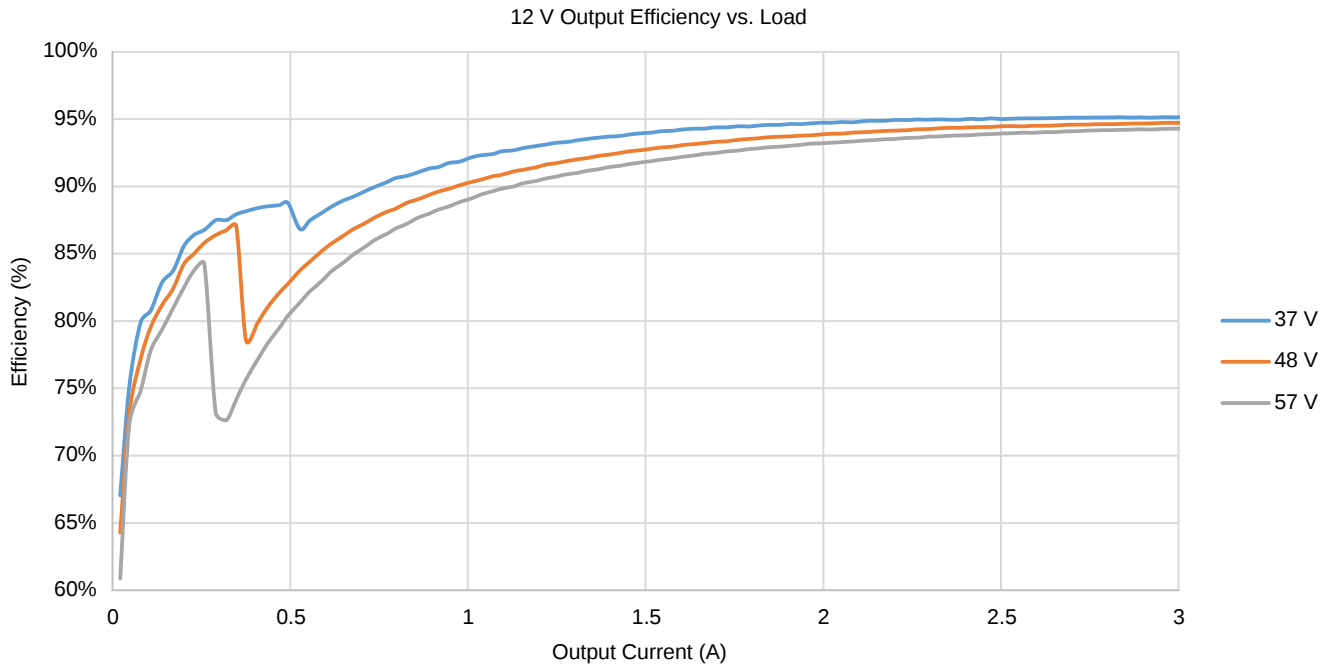


Figure 17. 12 V Efficiency Plot

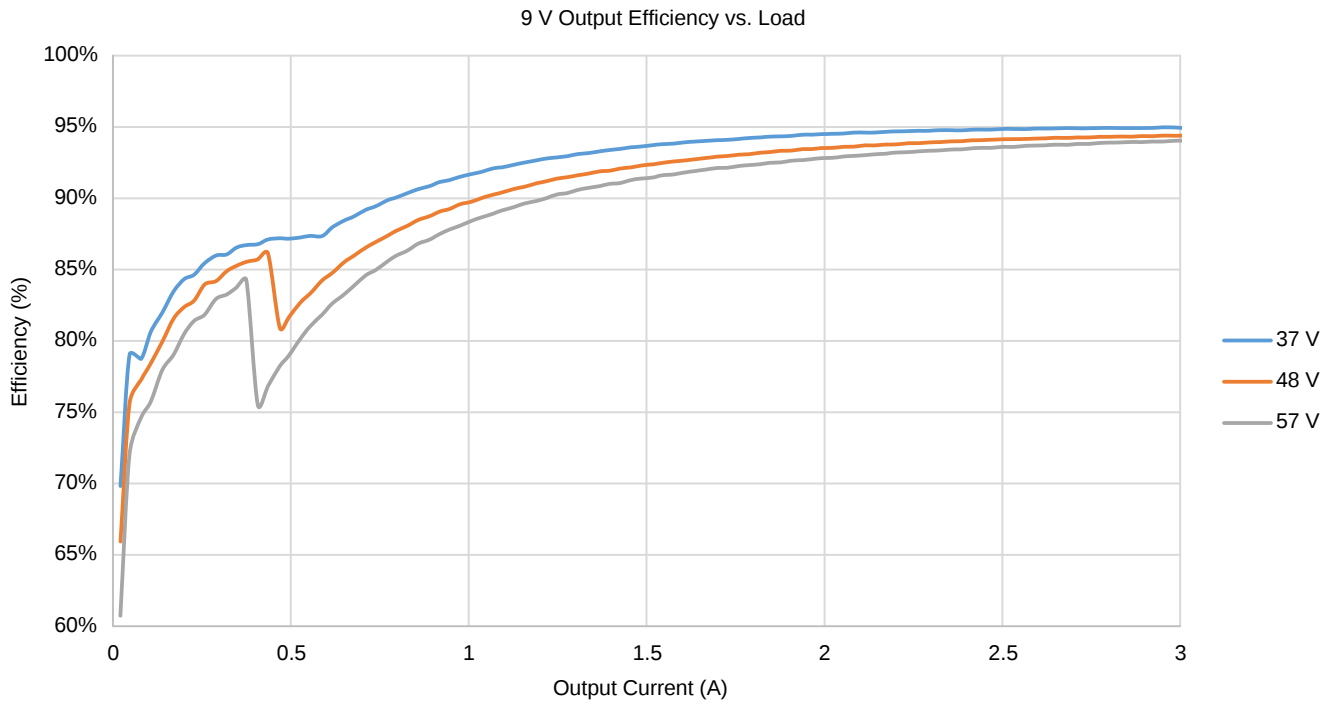


Figure 18. 9 V Efficiency Plot

EVBUM2776/D

5 V Output Efficiency vs. Load

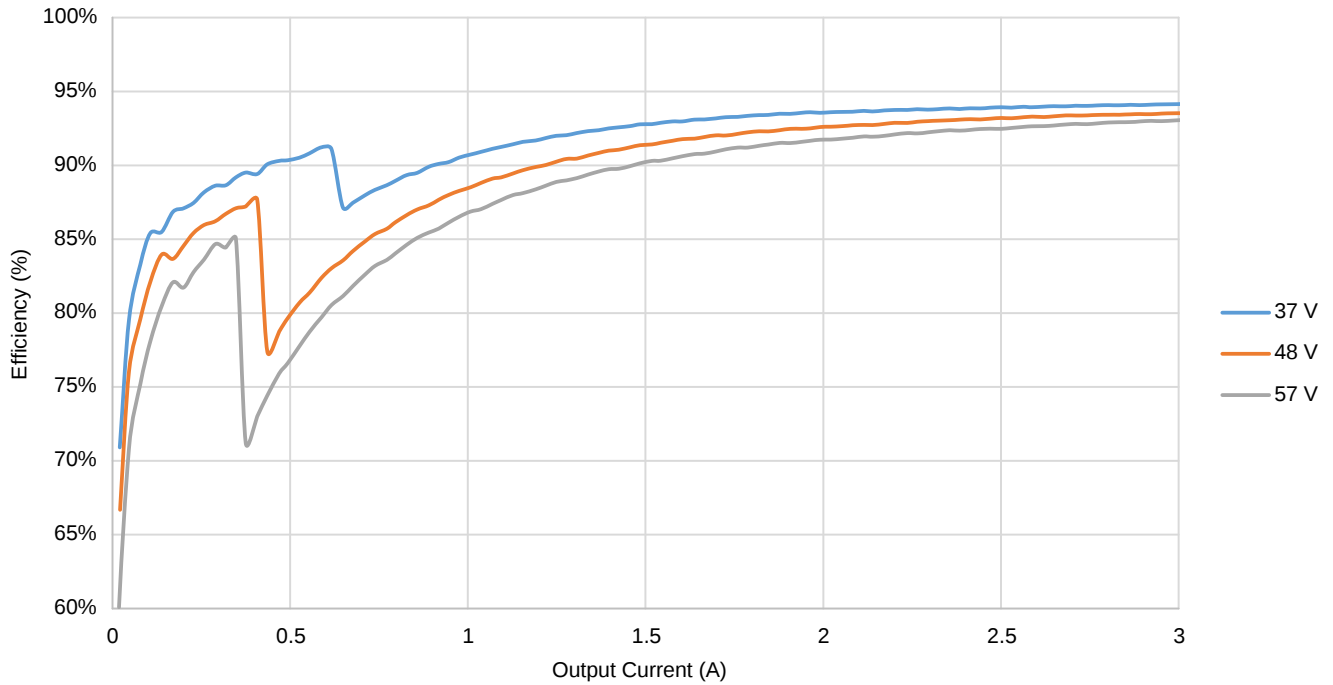


Figure 19. 5 V Efficiency Plot

OUTPUT RIPPLE

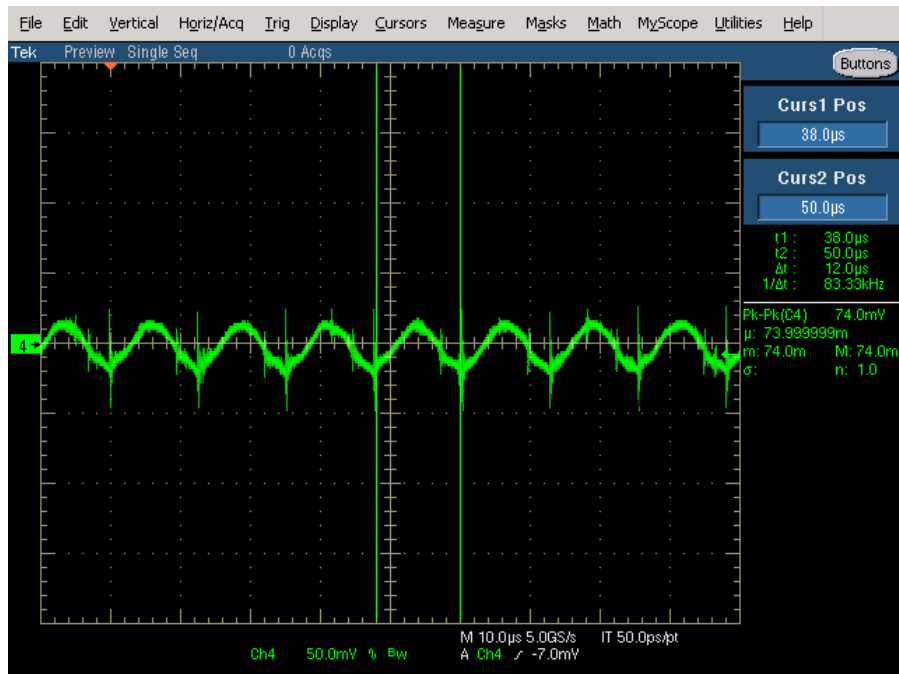


Figure 20. 37 Vin 5 Vout Output Ripple

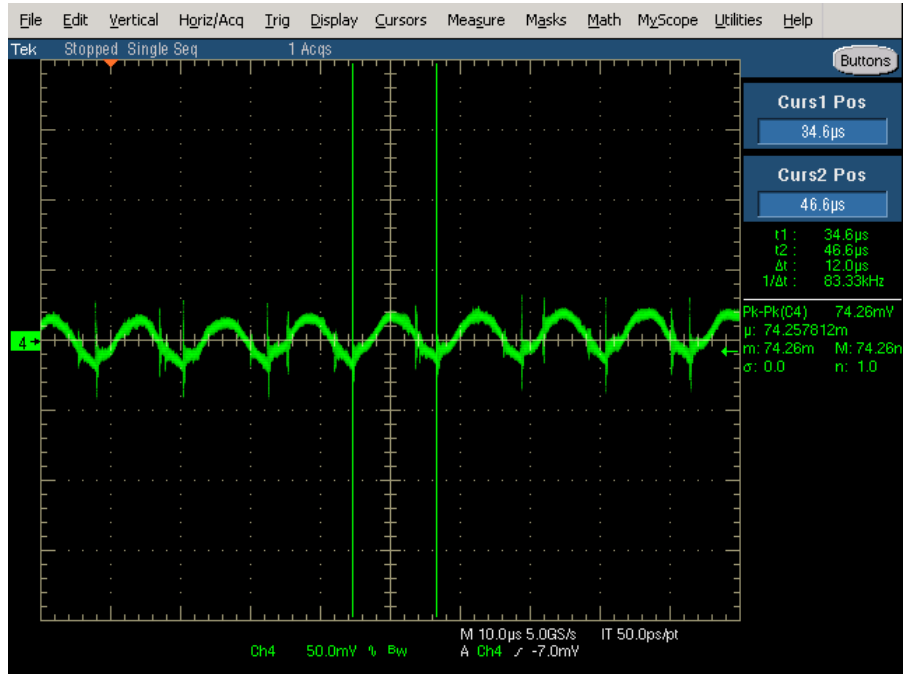


Figure 21. 48 Vin 5 Vout Output Ripple

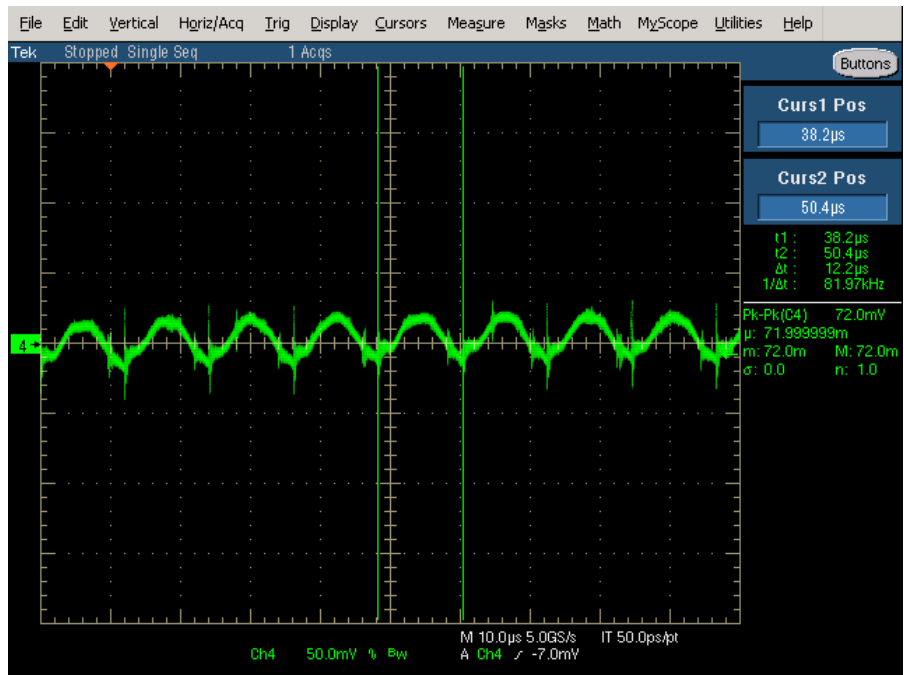


Figure 22. 57 Vin 5 Vout Output Ripple

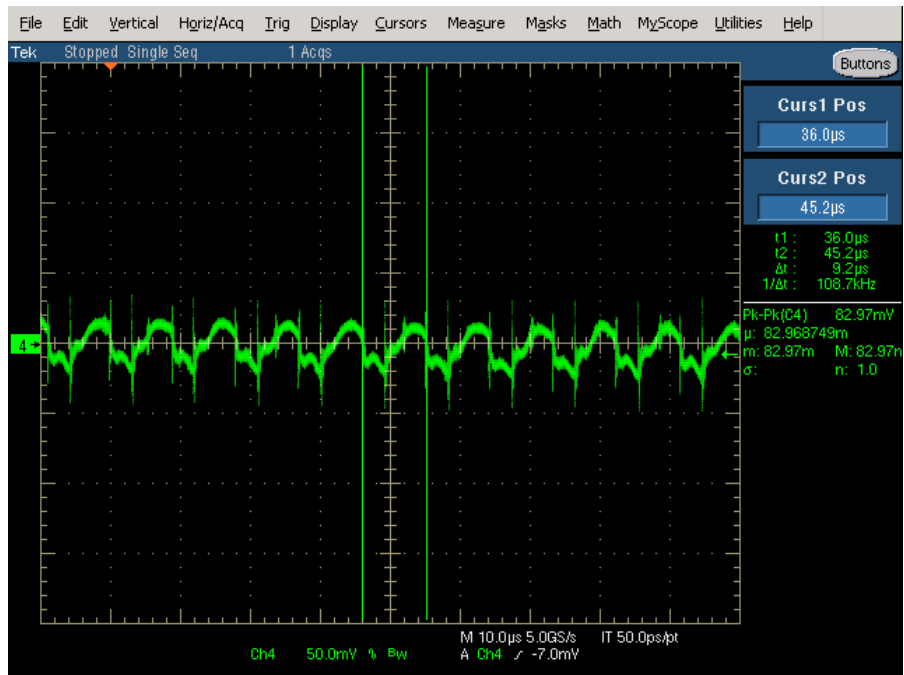


Figure 23. 37 Vin 9 Vout Output Ripple

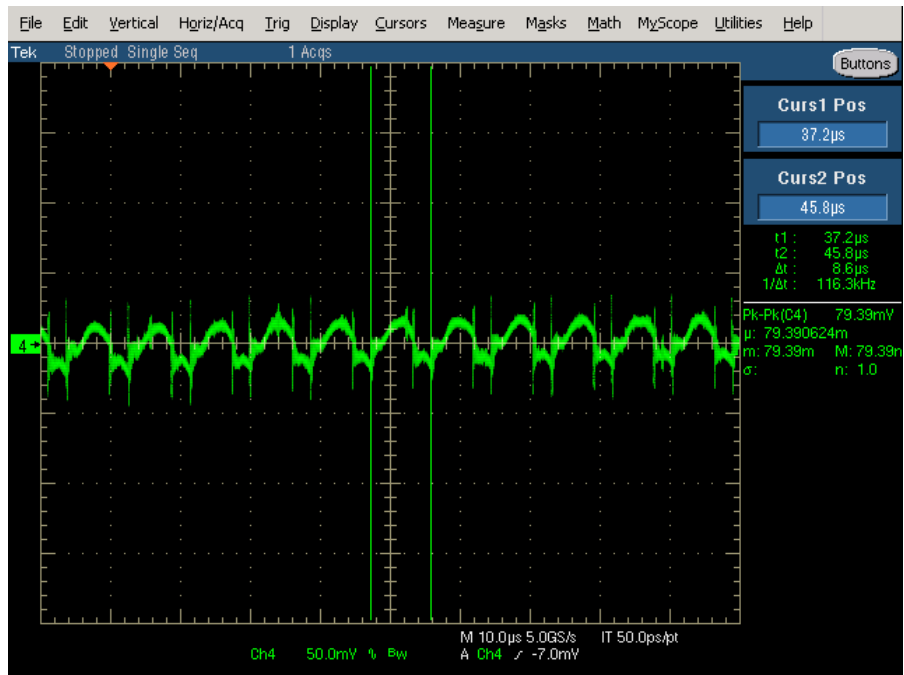


Figure 24. 48 Vin 9 Vout Output Ripple

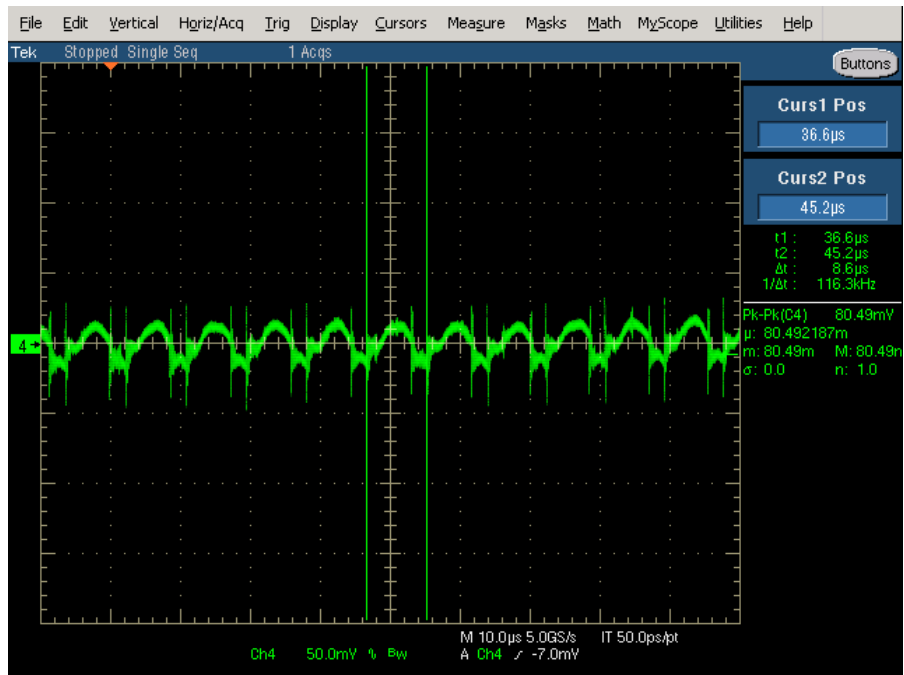


Figure 25. 57 Vin 9 Vout Output Ripple

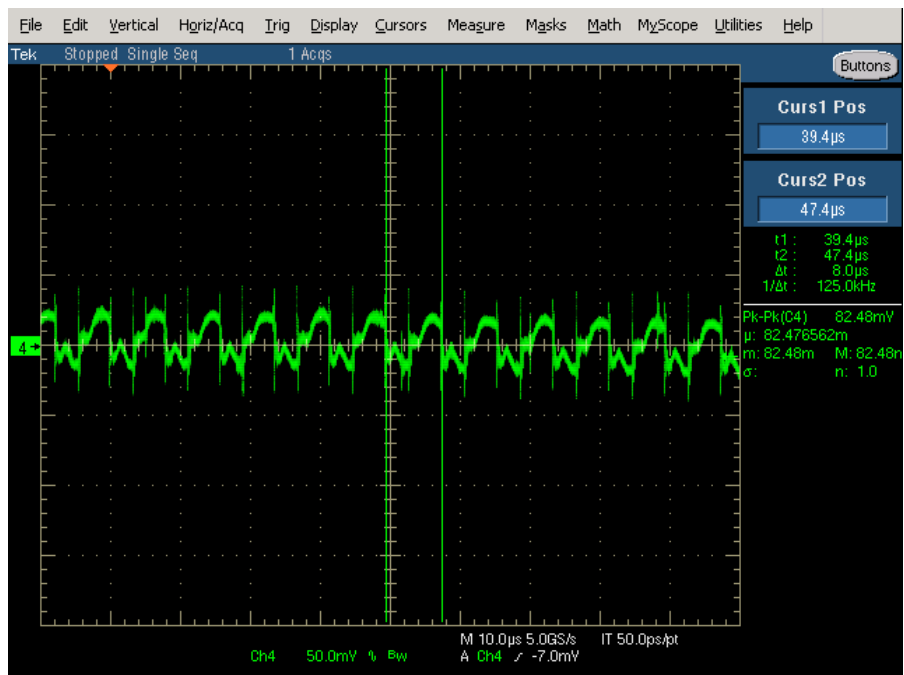


Figure 26. 37 Vin 12 Vout Output Ripple

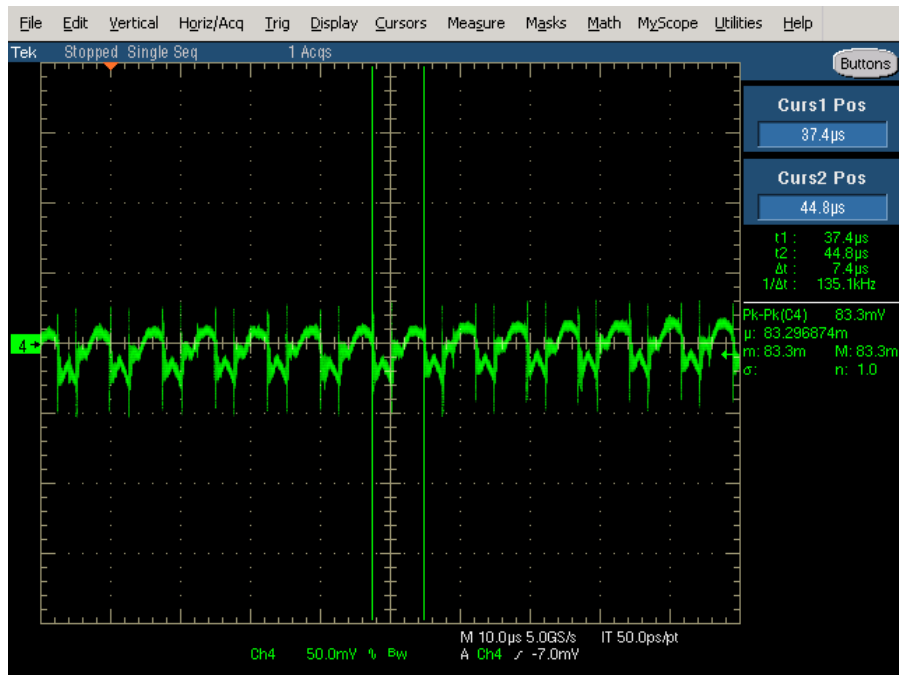


Figure 27. 48 Vin 12 Vout Output Ripple

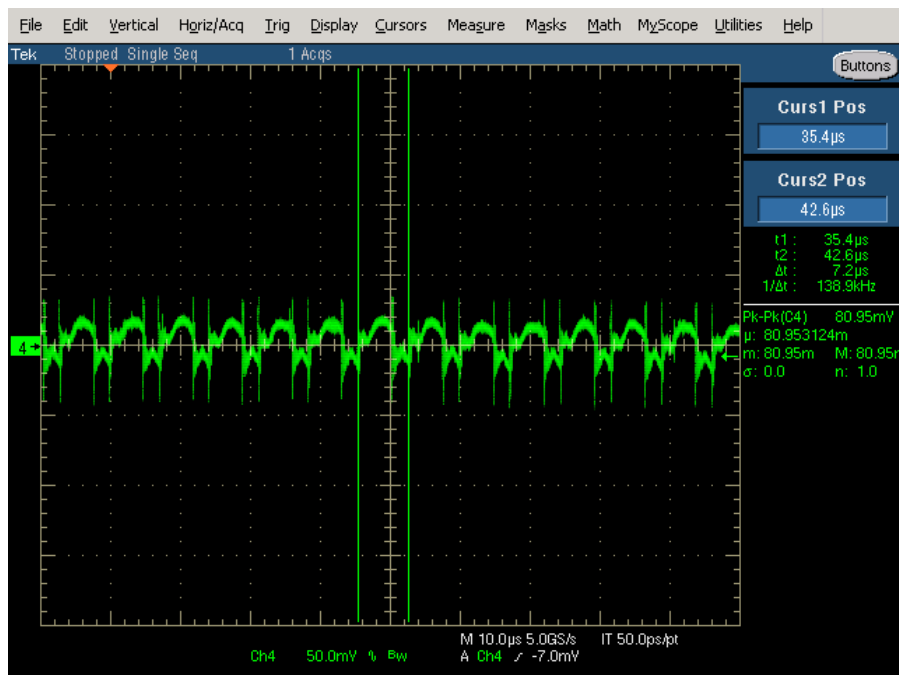


Figure 28. 57 Vin 12 Vout Output Ripple

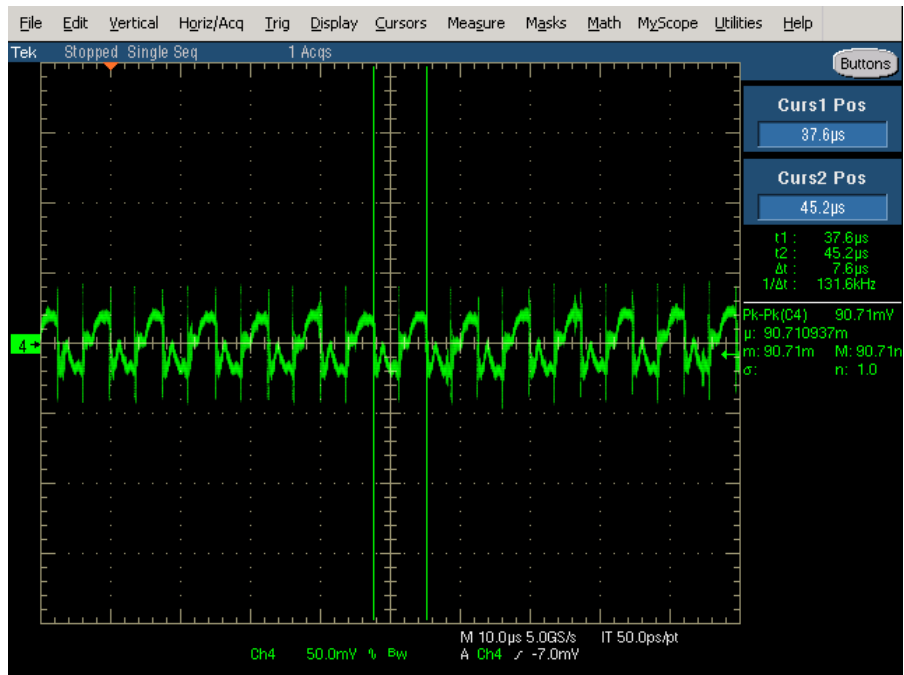


Figure 29. 37 Vin 15 Vout Output Ripple

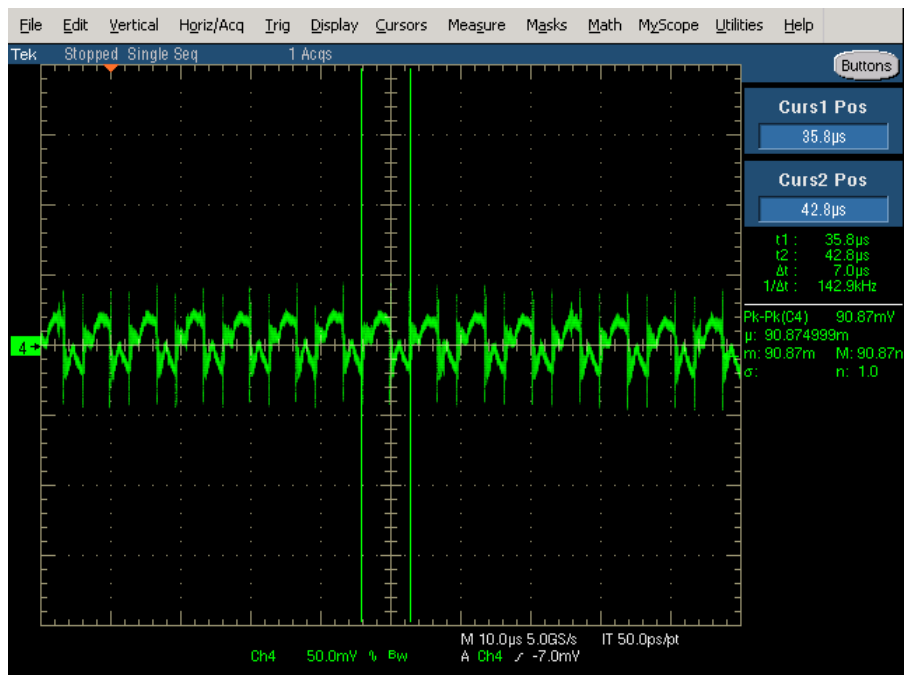


Figure 30. 48 Vin 15 Vout Output Ripple

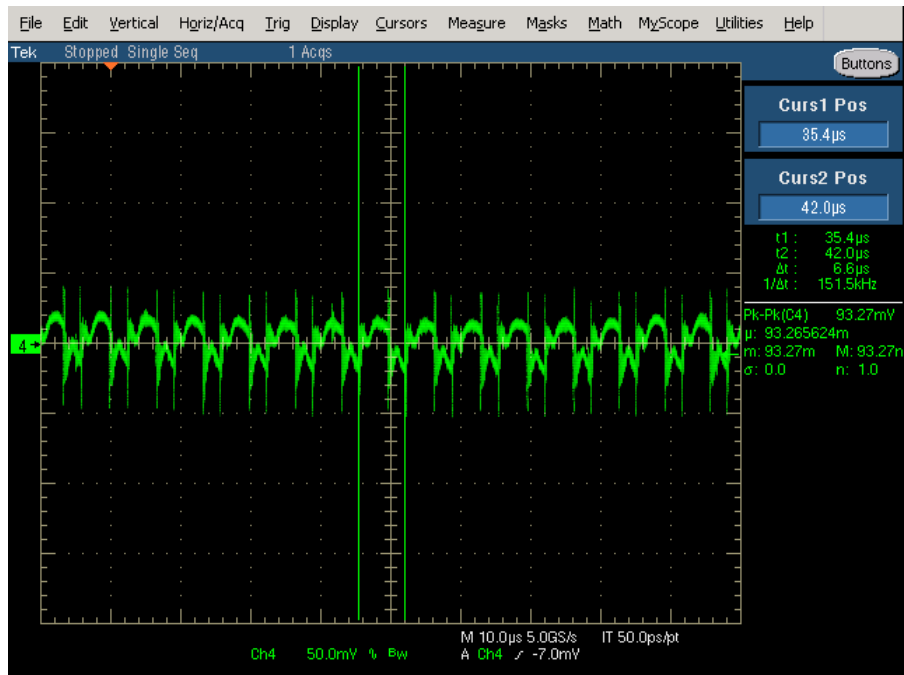


Figure 31. 57 Vin 15 Vout Output Ripple

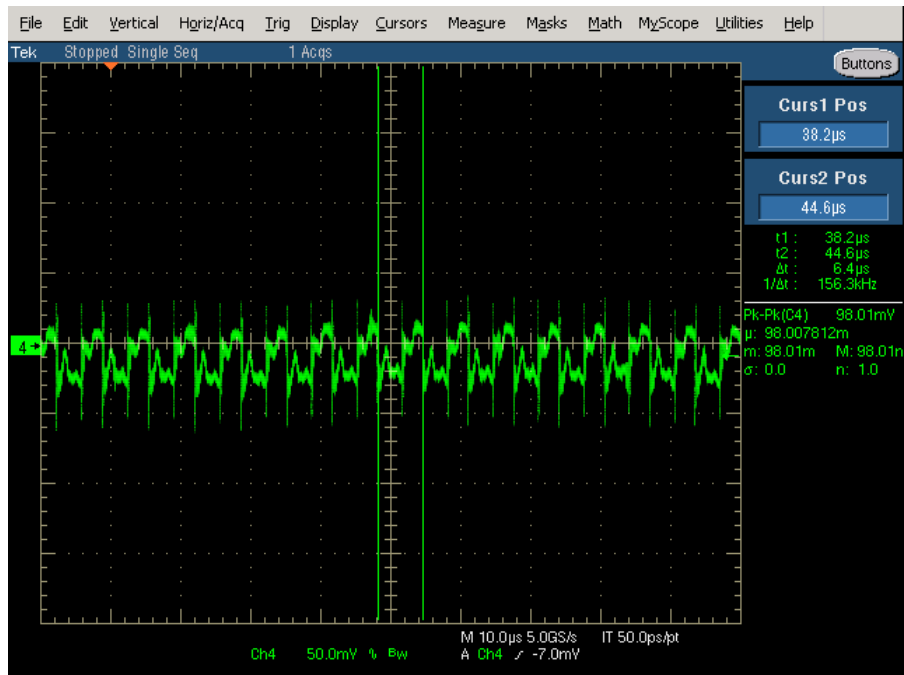


Figure 32. 37 Vin 20 Vout Output Ripple

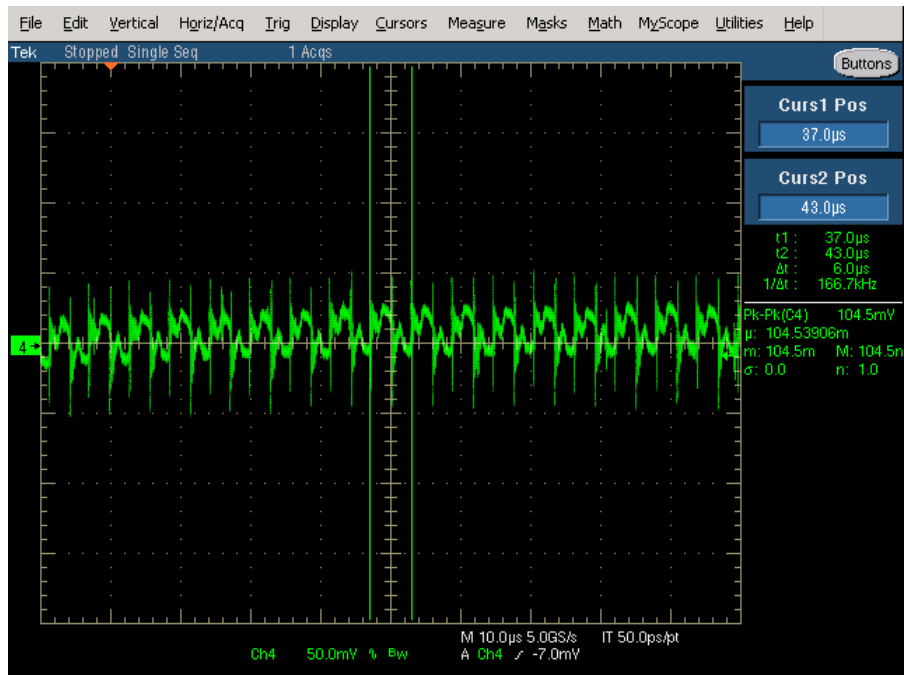


Figure 33. 48 Vin 20 Vout Output Ripple

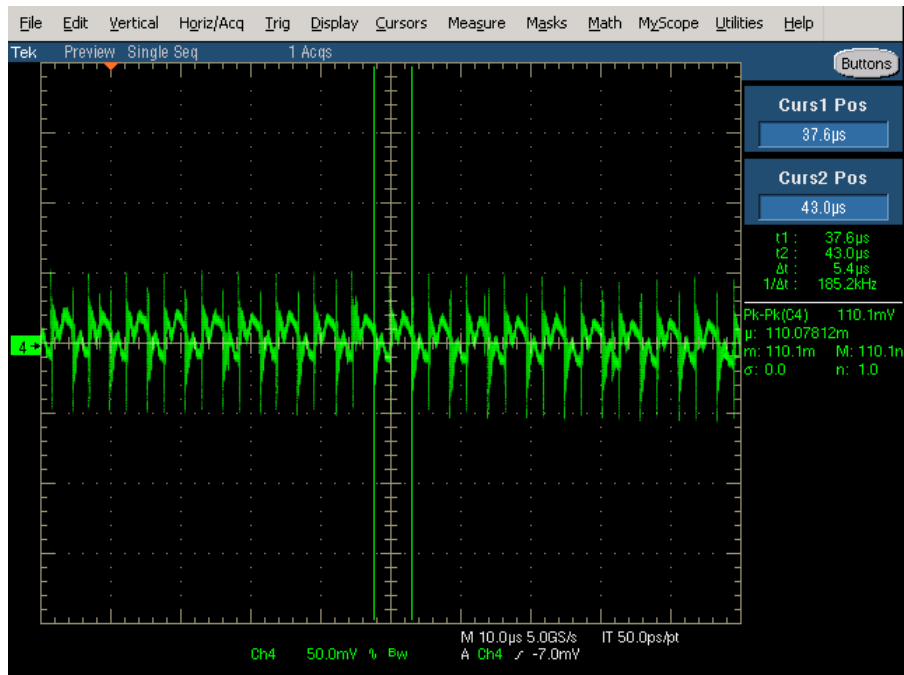


Figure 34. 57 Vin 20 Vout Output Ripple

Transient Response

(0.1 A – 3A / 2.25 A, 150 mA/μs, 20 ms)

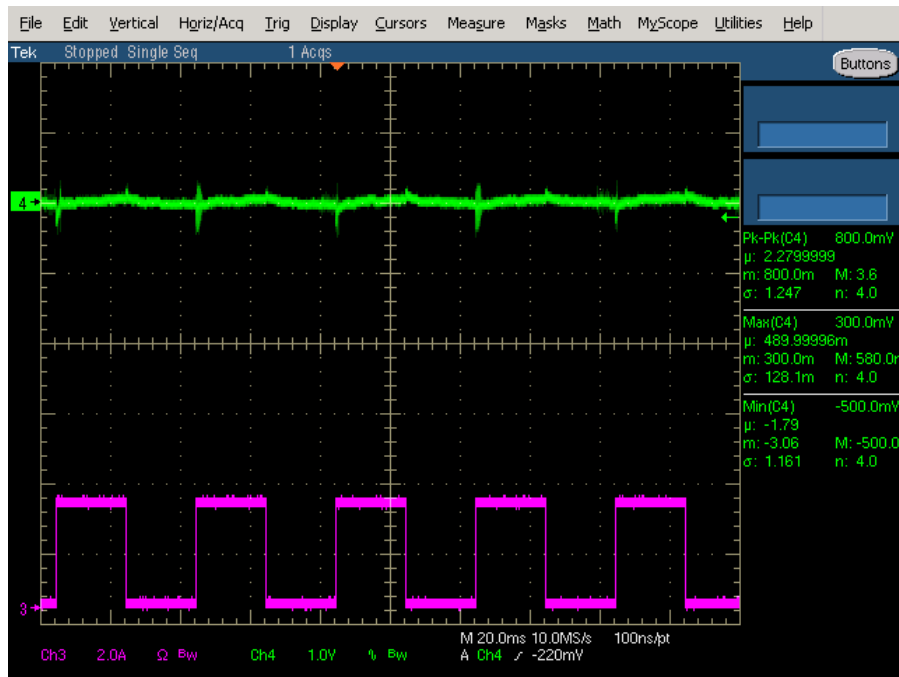


Figure 35. 37 Vin 5 Vout Transient Response

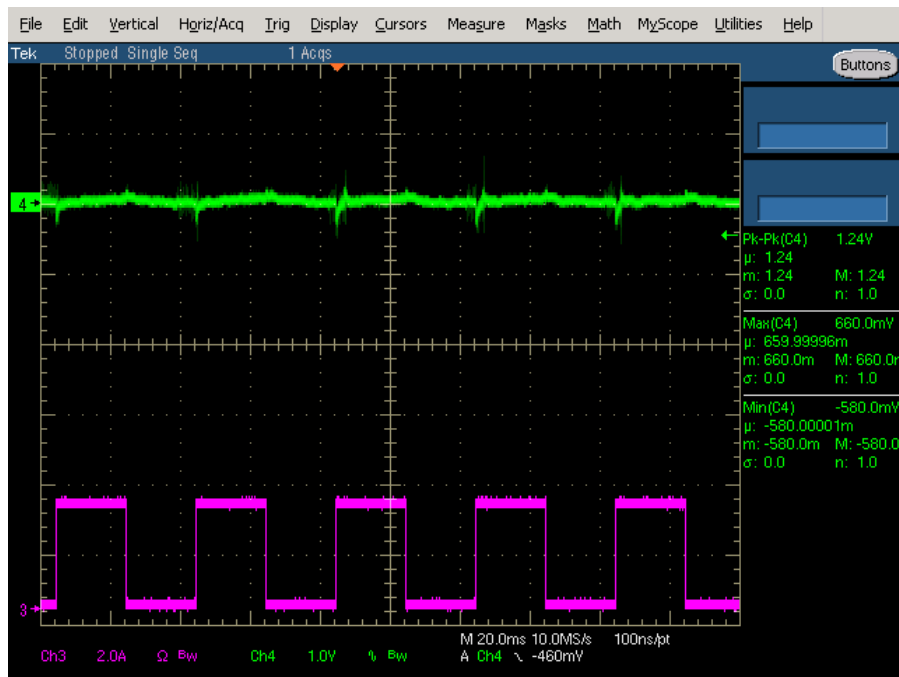


Figure 36. 48 Vin 5 Vout Transient Response

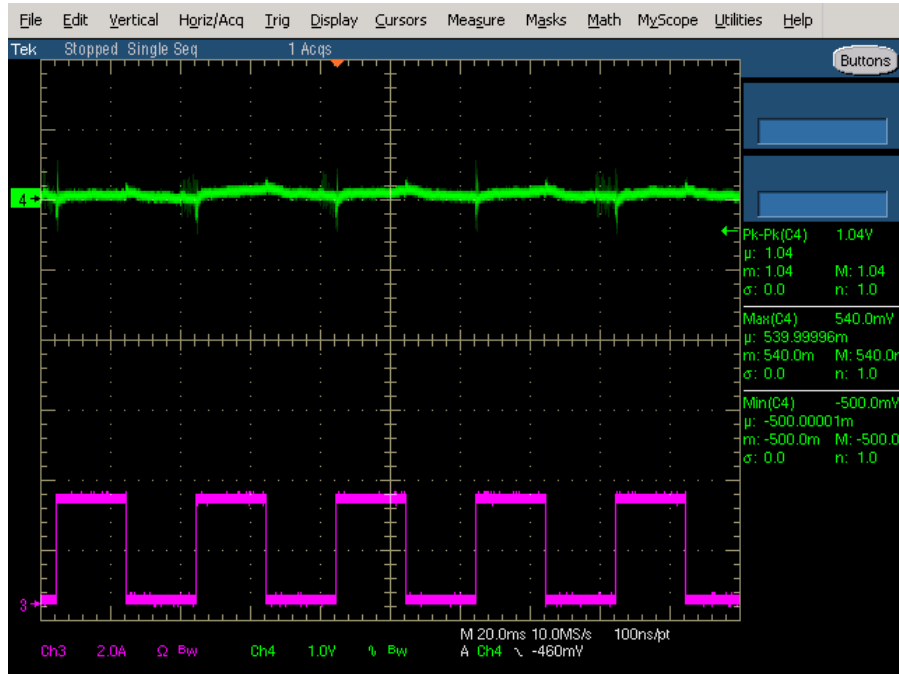


Figure 37. 57 Vin 5 Vout Transient Response



Figure 38. 37 Vin 9 Vout Transient Response



Figure 39. 48 Vin 9 Vout Transient Response



Figure 40. 57 Vin 9 Vout Transient Response



Figure 41. 37 Vin 12 Vout Transient Response

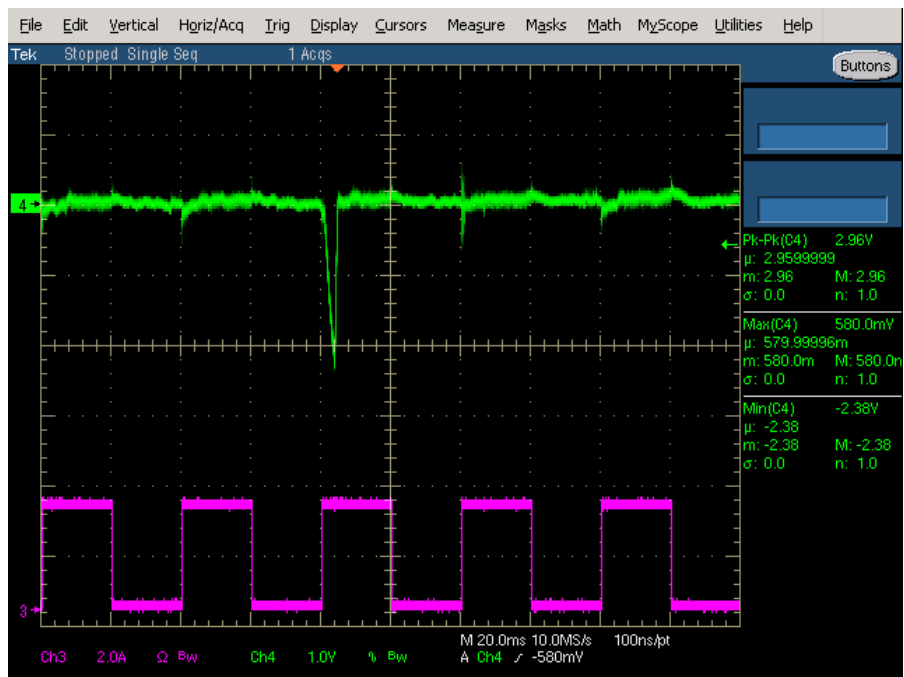


Figure 42. 48 Vin 12 Vout Transient Response



Figure 43. 57 Vin 12 Vout Transient Response

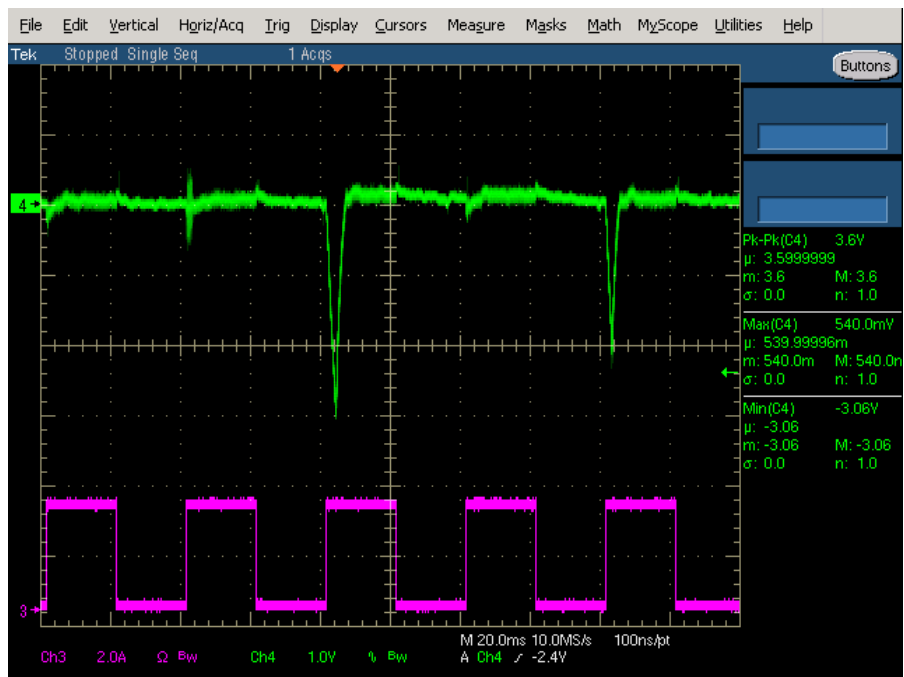


Figure 44. 37 Vin 15 Vout Transient Response

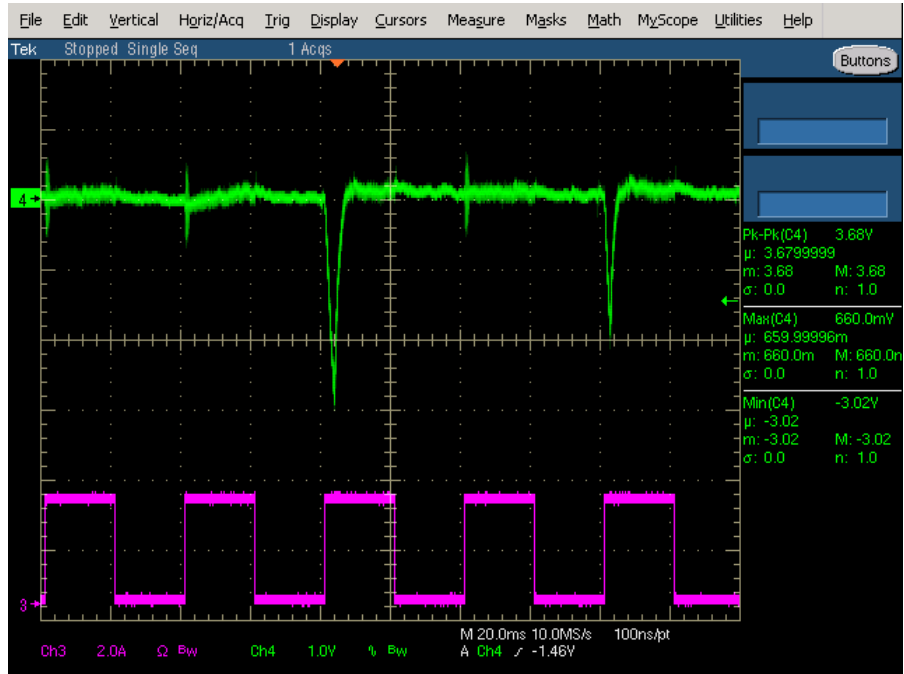


Figure 45. 48 Vin 15 Vout Transient Response



Figure 46. 57 Vin 15 Vout Transient Response



Figure 47. 37 Vin 20 Vout Transient Response



Figure 48. 48 Vin 20 Vout Transient Response

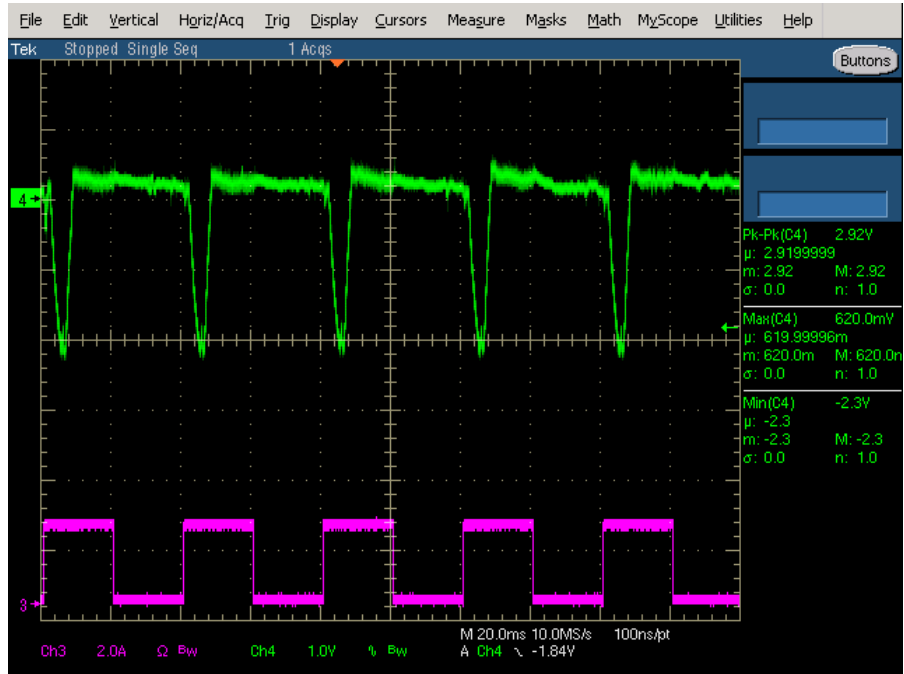
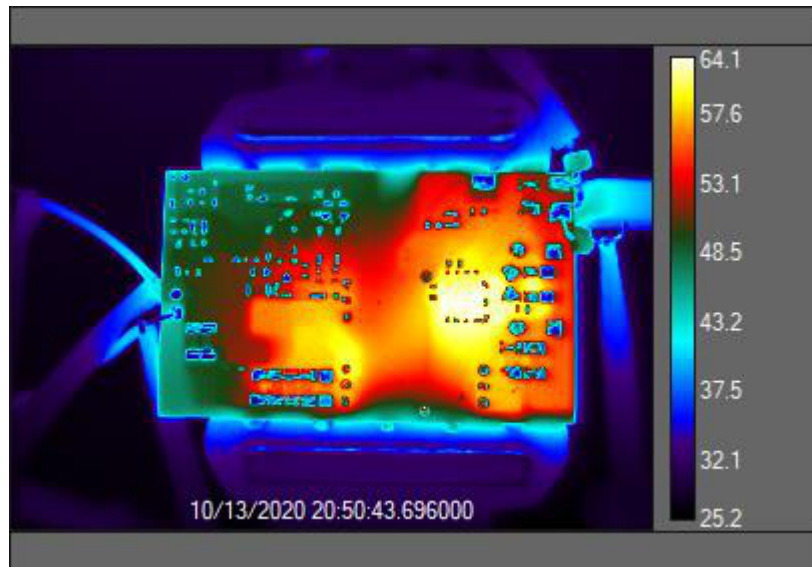


Figure 49. 57 Vin 20 Vout Transient Response

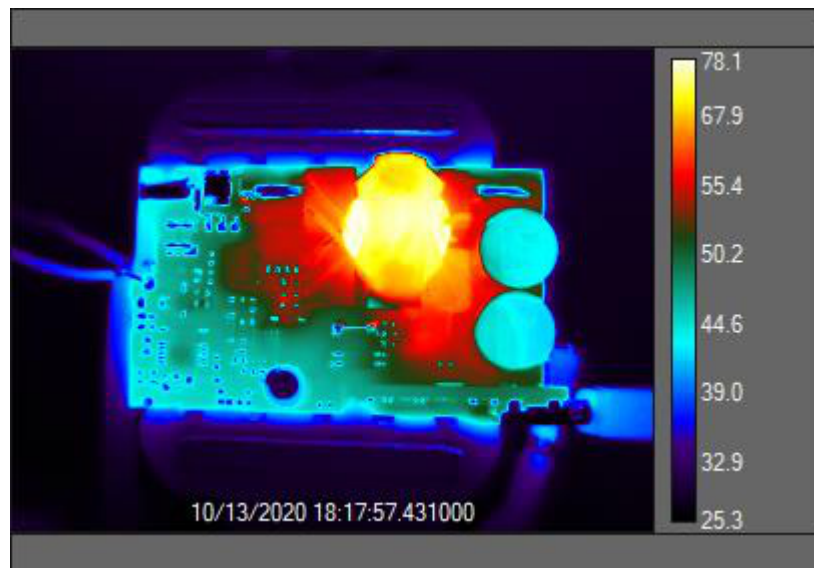
Thermal Data

All Temperatures shown in °Celsius



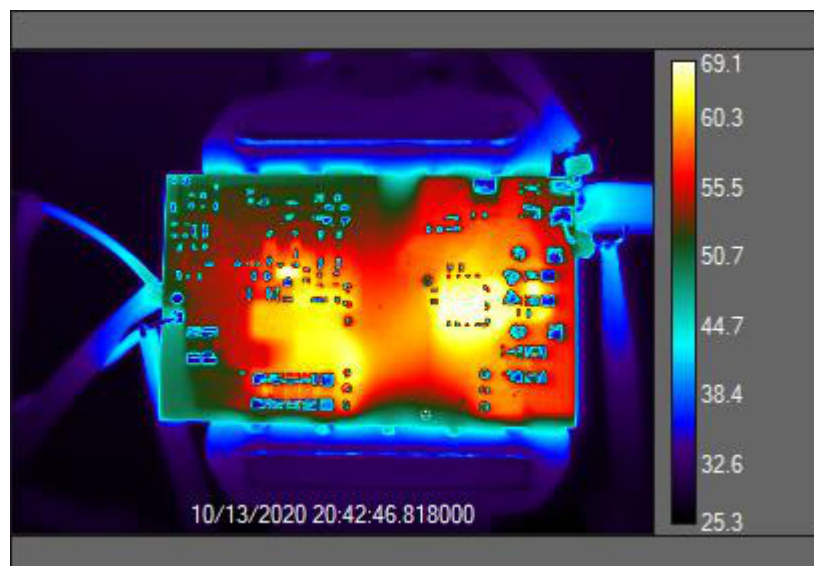
SRFET 64.10

Figure 50. 37 Vin 15 Vout Full Load Top



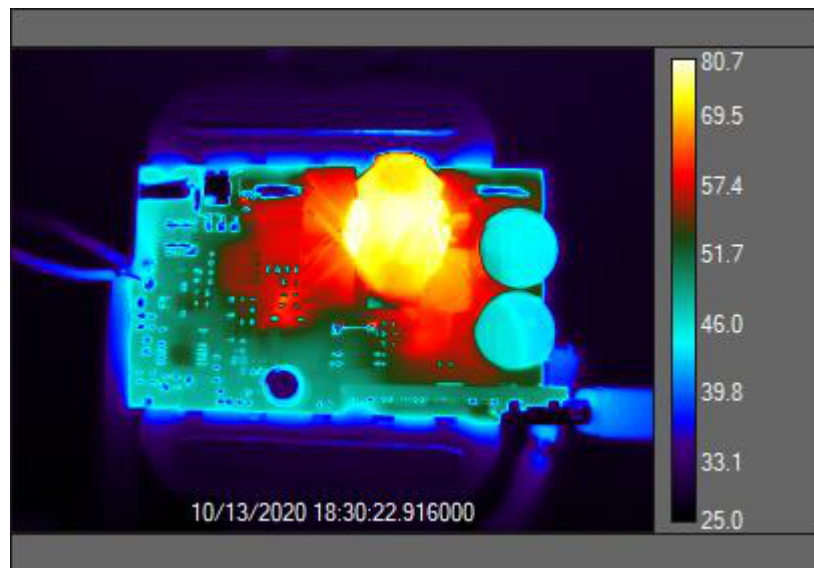
Transformer	Winding	LFET	HFET	NCP1568	NCP51530	NCP4308
73.83	78.14	52.3	56.48	47.02	47.65	56.74

Figure 51. 37 Vin 15 Vout Full Load Bottom



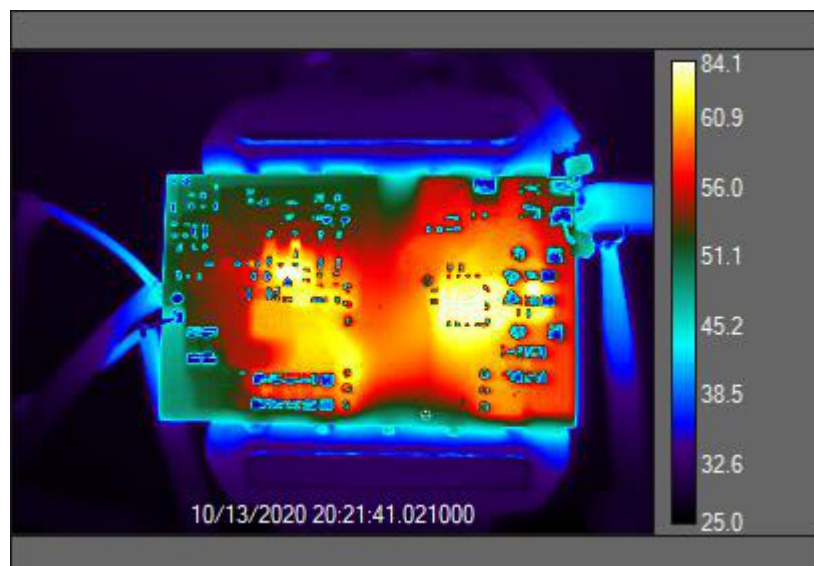
SRFET	66.17
-------	-------

Figure 52. 48 Vin 15 Vout Full Load Top



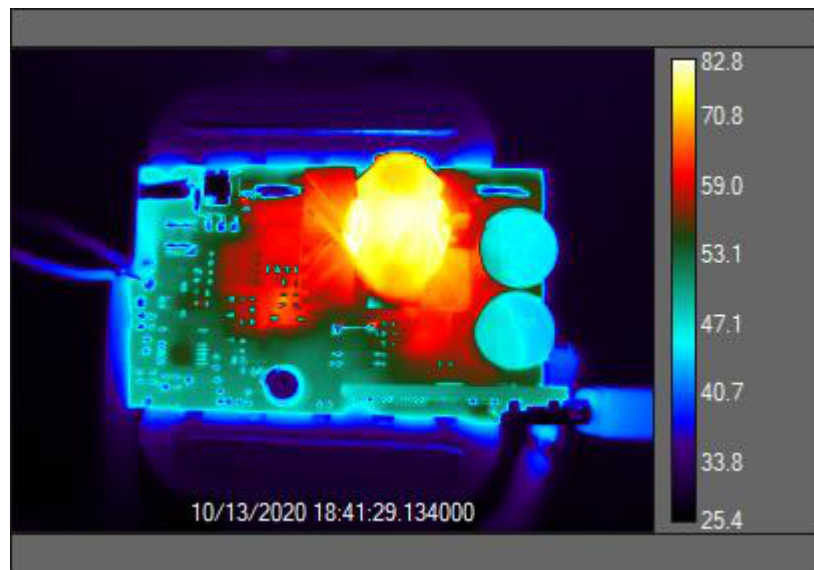
Transformer	Winding	LFET	HFET	NCP1568	NCP51530	NCP4308
77.33	80.71	55.26	59.35	51.57	52.42	58.95

Figure 53. 48 Vin 15 Vout Full Load Bottom



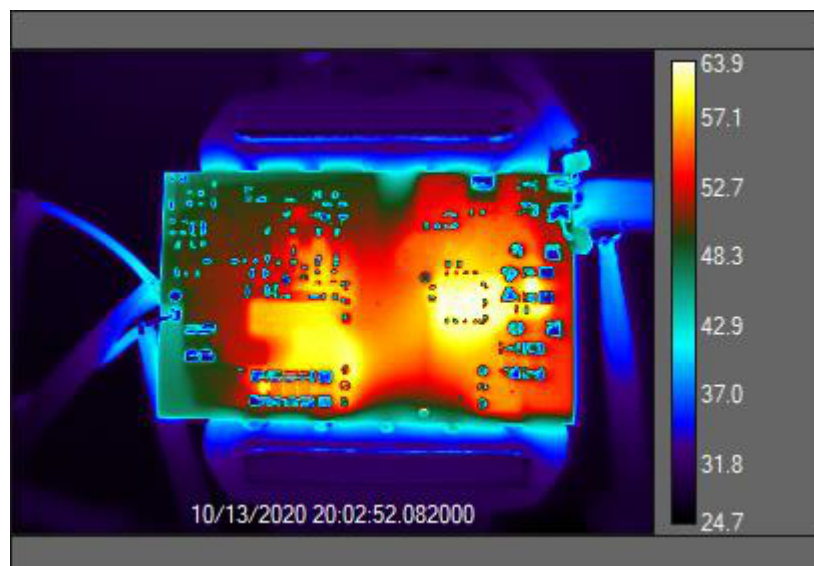
SRFET	66.92
-------	-------

Figure 54. 57 Vin 15 Vout Full Load Top



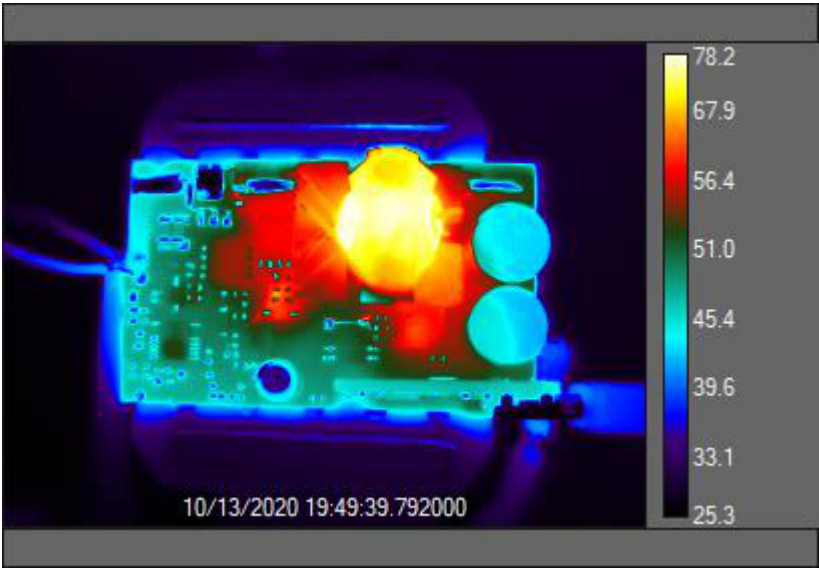
Transformer	Winding	LFET	HFET	NCP1568	NCP51530	NCP4308
79.95	82.84	57.88	61.58	54.04	55.69	60.25

Figure 55. 57 Vin 15 Vout Full Load Bottom



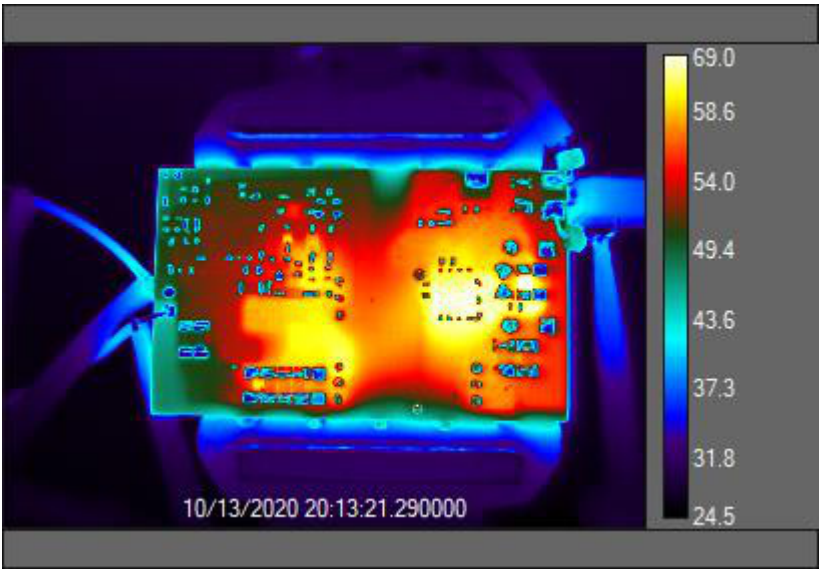
SRFET	62.38
-------	-------

Figure 56. 37 Vin 20 Vout Full Load Top



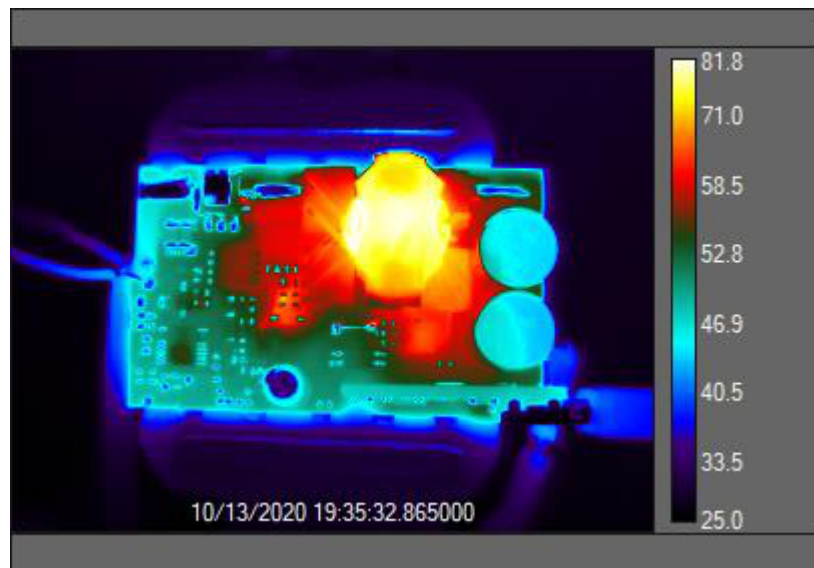
Transformer	Winding	LFET	HFET	NCP1568	NCP51530	NCP4308
75.15	78.23	54.72	57.96	51.85	51.96	58.93

Figure 57. 37 Vin 20 Vout Full Load Bottom



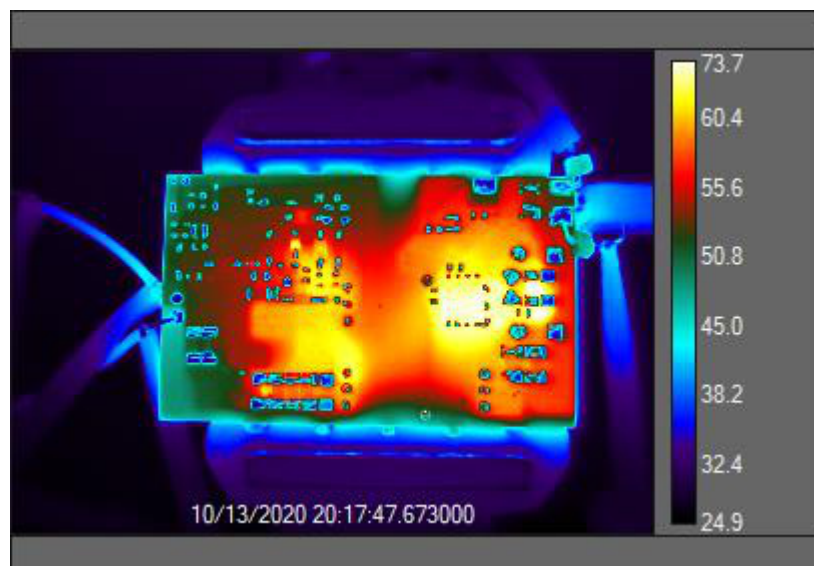
SRFET	64.47
-------	-------

Figure 58. 48 Vin 20 Vout Full Load Top



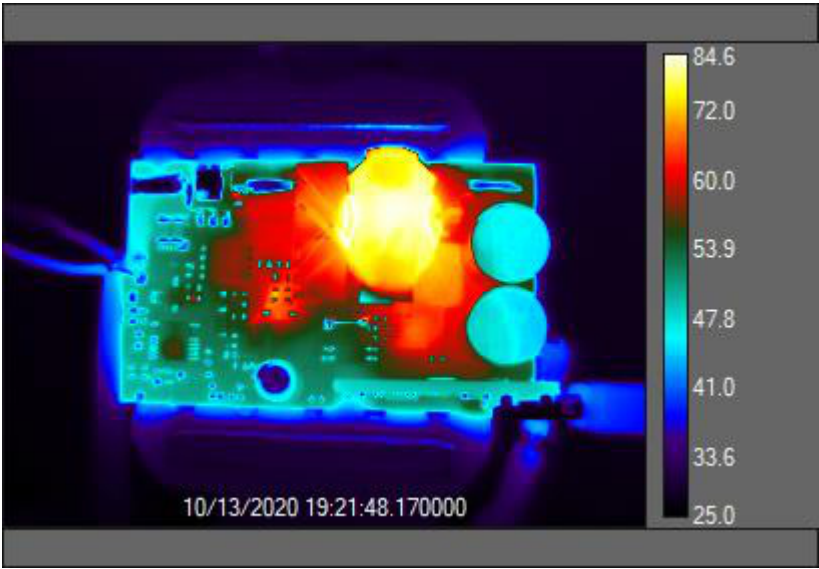
Transformer	Winding	LFET	HFET	NCP1568	NCP51530	NCP4308
79.47	81.8	56.28	60.44	53.95	54.32	61.87

Figure 59. 48 Vin 20 Vout Full Load Bottom



SRFET	66.49
-------	-------

Figure 60. 57 Vin 20 Vout Full Load Top



Transformer	Winding	LFET	HFET	NCP1568	NCP51530	NCP4308
83.12	84.65	57.74	61.94	55.61	56.19	64.02

Figure 61. 57 Vin 20 Vout Full Load Bottom

Table 1. BILL OF MATERIALS MAIN BOARD

Qty	Reference	Manufacturer	Manufacturer Part Number	Voltage Rating	Value	Footprint
1	Q4	ON Semiconductor	2N7002		60 V	SOT-23
1	C19	Würth Elektronik	885012206095	50 V	0.1 μ F	603
3	C21 C26 C39	TDK	CGA3E3X5R1H105K080AB	50 V	1.0 μ F	603
2	C24 C34	Würth Elektronik	885012206095	50 V	120 nF	603
1	C27	Würth Elektronik	885012006058	50 V	120 pF	603
1	C23	Würth Elektronik	885012006029	16 V	1 nF	603
1	C28	Würth Elektronik	885012206085	50 V	2.2 nF	603
1	C12	Würth Elektronik	885342006005	250 V	470 pF	603
2	C1 C17	Würth Elektronik	885012006021	16 V	47 pF	603
1	C29				DNI	603
2	C37 C40-41	Würth Elektronik	885012207103	50 V	1 μ F	805
1	C38	Taiyo Yuden	GMK325BJ226MM-P		22 μ F	1206
7	C2-8	Murata	GRM31CC72A475KE11L	100 V	4.7 μ F	1206
1	C9	Murata	GRM31CC72A475KE11L		DNI	1206
1	C16	STD			100 pF	1210
3	C10-11 C15	Taiyo Yuden	GMK325BJ226MM-P		22 μ F	1206
1	C20	Würth Elektronik	8853622100091		470 pF	1808
1	C30	Würth Elektronik	860020673014	50 V	68 μ F	(6.3)mm
2	C13 C14	Kemet	A750MS477M1EAAE015		470 μ F	TH-10x5mm
3	J19 J30-31	NA	NA		NA	2X3mm
6	D7-8 D10-12 D14	ON Semiconductor	MMSD4148T3G		100 V	SOD-123
1	D2	Vishay	VS-1EQH02-M3/H		200 V	DO-219AD
5	D1 D3 D5-6 D15	ON Semiconductor	MBR0530		30 V	SOD-123
1	D4	ON Semiconductor	MMSZ5250BT1G		20 V	SOD 123
1	D9	ON Semiconductor	MM3Z16VT1G		16 V	SOD-323
1	D13	ON Semiconductor			6.8 V	SOD-323
1	U1	CEL	FODM8801BV	80 V	1.17 V 50 mA	4-SMD, Gull Wing
1	T2	Würth Elektronik	7.5E+08		16uH Hitachi ML29D Core	RM6 12pin
3	L1-3				SHORT	
1	U3	ON Semiconductor	NCP1568C		30 V 1 MHz	TSSOP-16_SPE CIAL
1	U2	ON Semiconductor	NCP4308DMNTWG			DFN8-TPAD
1	U6	ON Semiconductor	NCP51530AMNTWG		NCP51530AM NTWG	DGN-10 W/PAD
2	Q1 Q3	ON Semiconductor	FDMS86255		150 V	PWR56
1	Q2	ON Semiconductor	FDMS86101		100 V	PWR56
2	R9 R26	Vishay	CRCW06030000Z0BC		0	603
2	R12 R20	Vishay	CRCW06030000Z0BC		0	603
2	R7 R11	Vishay	CRCW06031R00JNEA		1	603
1	R23	Vishay	CRCW060310R0JNEA		10	603
1	R3	Vishay	CRCW0603100RFKEA		100	603
1	R18	Vishay	CRCW0603100KFKEA		100k	603

Table 1. BILL OF MATERIALS MAIN BOARD (continued)

Qty	Reference	Manufacturer	Manufacturer Part Number	Voltage Rating	Value	Footprint
1	R13	Vishay	CRCW060310K0JNEA		10k	603
1	R2	Vishay	CRCW060311R0FKEA		11R0	603
1	R21	Yageo	RC0603FR-0715RL		15	603
1	R37	Vishay	CRCW060316K2FKEA		16.2k	603
1	R15	Yageo	RT0603FRE071KL		1k	603
1	R29	Vishay	CRCW06032K00FKEA		2.00k	603
1	R42	Vishay	CRCW06032M49FKEA		2.49M	603
2	R16-17	Vishay	CRCW06032K49FKEAC		2.49k	603
1	R30	Vishay	CRCW060320R0FKEA		20	603
1	R24	Panasonic	ERJ-3EKF4532V		30.9k	603
1	R1	Vishay	CRCW0603324RFKEA		324R	603
1	R27	Vishay	CRCW060338K3FKEA		38.3k	603
1	R38	Yageo	RC0603FR-074K99L		4.99k	603
1	R8	Vishay	CRCW060343R0JNEA		43	603
1	R19	Vishay	CRCW060344K2FKEA		44.2k	603
1	R41	Vishay	CRCW0603475KFKEA		475k	603
2	R10 R22	Vishay	CRCW060347K0JNEA		47k	603
3	R31-32 R40	Vishay	??		4R99	603
1	R33				DNI	603
1	R39	Vishay	CRCW06031R00JNEA		DNI	603
2	R34-35				DNI	603
2	R25 R28	??	??		DNI	603
2	R6 R14	Vishay	CRCW1206100RJNEA		100	1206
1	R4	Vishay			20k	1206
1	R5	Vishay			DNI	1206
1	T1	Würth	7.5E+08		1:100	SMD-8.4x7.2mm

EVBUM2776/D

Table 2. BILL OF MATERIALS DAUGHTER CARD

Qty	Reference	Manufacturer	Manufacturer Part Number	Voltage Rating	Value	Footprint
1	C46	Kemet	C0402C681G5GACTU	25 V	680 pF	402
1	C4			25 V	DNI	402
2	C37 C44	TDK	CGA2B2X7R1H472K050BE	50 V	4.7 nF	402
1	C30	Samsung	CL10A105KL8NNNC	35 V	1.0 μ F	603
1	R32	Vishay	CRCW040210R0FKED		10R	402
1	R21	Vishay	CRCW0402120KJNED		120k	402
1	R34	Vishay	CRCW040213K0JNED		13k	402
2	R40 R42	Vishay	CRCW040210R0FKED		10R	402
1	R39	Yageo	RC0402FR-07100KL		100k	402
1	R53	Yageo	RC0402FR-07100KL		100k	402
1	R25	Vishay	CRCW040210K0FKEDC		10k	402
1	R35	Vishay	CRCW040282K5FKEDC		82.5k	402
1	R47	Vishay	CRCW04021K00FKTD		1k	402
3	J2 J4 J6	NA	NA		NA	2x3 mm
1	U1	ON Semiconductor	FUSB3307			QFNW20
1	C48	Yageo	CC0402JRX7R9BB102	50 V	1 nF	402
2	C34-35	Murata	GRM1555C1H391JA01J	50 V	390 pF	402
1	Q3	ON Semiconductor	FDMC012N03			Power33
1	R31	Yageo	AC0805FR-0740R2L		40R2	805
4	D1-2 D6 D10	ON Semiconductor	NSPU3051N2T5G		7V	X2DFN2
1	C21	AVX	0603DD105KAT2A	35 V	1 μ F	603
1	CON1	Wurth	632723300011		NA	THT/SM
1	R26	Visahy	WSLP12065L000FEA		5 m Ω	1206

onsemi, **onsemi**, and other names, marks, and brands are registered and/or common law trademarks of Semiconductor Components Industries, LLC dba "**onsemi**" or its affiliates and/or subsidiaries in the United States and/or other countries. **onsemi** owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of **onsemi**'s product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent-Marking.pdf. **onsemi** is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

The evaluation board/kit (research and development board/kit) (hereinafter the "board") is not a finished product and is not available for sale to consumers. The board is only intended for research, development, demonstration and evaluation purposes and will only be used in laboratory/development areas by persons with an engineering/technical training and familiar with the risks associated with handling electrical/mechanical components, systems and subsystems. This person assumes full responsibility/liability for proper and safe handling. Any other use, resale or redistribution for any other purpose is strictly prohibited.

THE BOARD IS PROVIDED BY ONSEMI TO YOU "AS IS" AND WITHOUT ANY REPRESENTATIONS OR WARRANTIES WHATSOEVER. WITHOUT LIMITING THE FOREGOING, ONSEMI (AND ITS LICENSORS/SUPPLIERS) HEREBY DISCLAIMS ANY AND ALL REPRESENTATIONS AND WARRANTIES IN RELATION TO THE BOARD, ANY MODIFICATIONS, OR THIS AGREEMENT, WHETHER EXPRESS, IMPLIED, STATUTORY OR OTHERWISE, INCLUDING WITHOUT LIMITATION ANY AND ALL REPRESENTATIONS AND WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, TITLE, NON-INFRINGEMENT, AND THOSE ARISING FROM A COURSE OF DEALING, TRADE USAGE, TRADE CUSTOM OR TRADE PRACTICE.

onsemi reserves the right to make changes without further notice to any board.

You are responsible for determining whether the board will be suitable for your intended use or application or will achieve your intended results. Prior to using or distributing any systems that have been evaluated, designed or tested using the board, you agree to test and validate your design to confirm the functionality for your application. Any technical, applications or design information or advice, quality characterization, reliability data or other services provided by **onsemi** shall not constitute any representation or warranty by **onsemi**, and no additional obligations or liabilities shall arise from **onsemi** having provided such information or services.

onsemi products including the boards are not designed, intended, or authorized for use in life support systems, or any FDA Class 3 medical devices or medical devices with a similar or equivalent classification in a foreign jurisdiction, or any devices intended for implantation in the human body. You agree to indemnify, defend and hold harmless **onsemi**, its directors, officers, employees, representatives, agents, subsidiaries, affiliates, distributors, and assigns, against any and all liabilities, losses, costs, damages, judgments, and expenses, arising out of any claim, demand, investigation, lawsuit, regulatory action or cause of action arising out of or associated with any unauthorized use, even if such claim alleges that **onsemi** was negligent regarding the design or manufacture of any products and/or the board.

This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and may not meet the technical requirements of these or other related directives.

FCC WARNING – This evaluation board/kit is intended for use for engineering development, demonstration, or evaluation purposes only and is not considered by **onsemi** to be a finished end product fit for general consumer use. It may generate, use, or radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment may cause interference with radio communications, in which case the user shall be responsible, at its expense, to take whatever measures may be required to correct this interference.

onsemi does not convey any license under its patent rights nor the rights of others.

LIMITATIONS OF LIABILITY: **onsemi** shall not be liable for any special, consequential, incidental, indirect or punitive damages, including, but not limited to the costs of requalification, delay, loss of profits or goodwill, arising out of or in connection with the board, even if **onsemi** is advised of the possibility of such damages. In no event shall **onsemi**'s aggregate liability from any obligation arising out of or in connection with the board, under any theory of liability, exceed the purchase price paid for the board, if any.

The board is provided to you subject to the license and other terms per **onsemi**'s standard terms and conditions of sale. For more information and documentation, please visit www.onsemi.com.

ADDITIONAL INFORMATION

TECHNICAL PUBLICATIONS:

Technical Library: www.onsemi.com/design/resources/technical-documentation
onsemi Website: www.onsemi.com

ONLINE SUPPORT: www.onsemi.com/support

For additional information, please contact your local Sales Representative at www.onsemi.com/support/sales